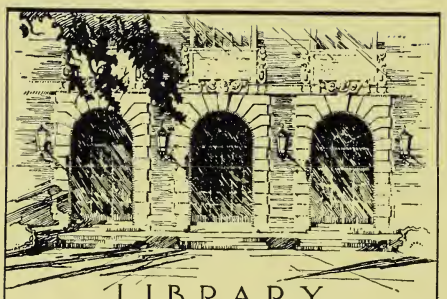

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DWIGHT H. GREEN, Governor

TRANSACTIONS
OF THE
ILLINOIS STATE ACADEMY OF SCIENCE

VOLUME 34 SEPTEMBER, 1941 NUMBER 1

Special Papers Presented at the Thirty-fourth Annual Meeting
Evanston, Illinois, May, 1941

Memoirs

Edited by Grace Needham Oliver

DEPARTMENT OF REGISTRATION AND EDUCATION
ILLINOIS STATE MUSEUM DIVISION, CENTENNIAL BUILDING
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DWIGHT H. GREEN, *Governor*

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Printed September, 1941

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TRANSACTIONS OF THE ILLINOIS STATE ACADEMY OF SCIENCE

Volume 34 September, 1941 Number 1

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ANNOUNCEMENTS

Attention is directed to the fact that the Committee on Research Grants of the Illinois State Academy of Science has at its disposal a small sum of money to be disbursed in support of worthy research projects. Applications for grants will be accepted up to and including March 31, 1942. It is customary to give preference to scientists connected with the smaller institutions of the state.

Requests for grants should be accompanied by a brief statement of the training and experience of the applicant, the purpose of the investigation, and the estimated cost. Previous publications should be listed. At least two letters of recommendation should be transmitted directly by their authors. Correspondence may be addressed to William C. Rose, Chairman, Department of Chemistry, University of Illinois, Urbana, Illinois.

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1942 MEETING — URBANA — MAY 8-9

FUNGI AND MAN*

VERNE O. GRAHAM

A few years ago the speaker was deeply concerned over a number of ecological problems such as why more fungi occur during autumn than in the springtime, when an observer ventured the chance remark,—"Why spend so much time on these peculiar forms of life? Are they of any value to man?" Two answers to these questions may be proposed. The first is supported by all true scientists and includes the idea that all pure science is, across the centuries, of far greater value than the form which for personal reasons goes forth to find evidence in support of a proposition or conclusion arrived at from inadequate data. The second is based on our knowledge of the harm done by this great group of plants in causing decay of economic products. We know much more about their destruction than their control; we see the collapse of a structure weakened by the inroads of wood-inhabiting fungi; we are made aware of the constant expense incurred by replacement of decayed ties and timbers along our railroads; we note the dead and dying trees in our forests, and sometimes try to salvage some of the lumber before decay has completely destroyed its value. We look at fungi as food and hope that here we may find sufficient defense for their existence, and are dismayed to discover food value but little in excess of that found in cabbage. All these are superficial, and yield but little toward our understanding of this great group of plants and wherein they fit in the economy of life.

The greatest contribution of fungi to the balance of life is related to the decay of organic material. We need but imagine the effect of removal of all decay activities from our forests. Trees broken by wind or lightning crash to the earth year after year and lie until the forces of decay or fire change their nature from debris to soil. Unaffected by these forces the forest eventually would accomplish its own suffocation, mounting fallen timbers would heap higher and ever higher to mingle, first, with the lower branches, kill them by suffocation, and finally, bring death to the entire forest. Fungi increase in number with food supply, the debris of the forest furnishing food for countless numbers of them; with more debris more fungi appear; with decrease in this food supply occurs a corresponding decrease in fungi. In a complicated relationship these agencies continue to exist interdependent in their life needs. A dead branch lies on the ground but a short time before the scavengers of the plant world begin their work upon it. Sometimes the reduction process is accomplished by a single visible species, sometimes by many causing several forms of decay.

Each autumn, leaves carpet the earth, but in a few weeks all have disappeared except for a few kinds. Maple leaves color and make beautiful the autumn forest but on the ground they soon decay. Poplar leaves are more persistent as part of the forest carpet; not until spring has decay completely decomposed them. The dominant in any such carpet in this region is a mixture of leaves from some of the nine species of oak. The thick, leathery leaves and the presence of tannic acid make possible their persistence for more than a year. As rainfall slowly leaches preservatives from them, decay gradually softens the tough protective covering to produce a leafy substratum for the growth of many species of Marasmius, Collybia, and other small pileate fungi.

What are some of the environmental results of the carpet of leaves? The first important one accrues from the blanket-like covering of the soil tending to retain heat within the soil when the outside air is cold, and the prevention of warming processes from the outside during the time when the air is much warmer than the soil. Consequently the soil retains sufficient heat during the autumn months for the growth of terrestrial fungi long after the normal expectancy. During November it is not

*Address of the Retiring President before the general Academy membership met in convention at Evanston, Illinois, May 1-2-3, 1941.

unusual to find such species as Hygrophorus Russula and Tricholoma personatum among others pushing the leafy covering upward, tent-like, to gain position for spore dissemination. During this time humus is abundant and moisture has been retained sufficient for the wide spread development of mycelium. These conditions are ideally favorable for fructifications, providing the precipitation is at least average, and if no unusually long periods with freezing temperatures have occurred to penetrate the leafy-blanket and halt the development of the vegetative structure from which carpophores arise. With average autumnal conditions prevailing, the beneath-the-leaves habitat is populated by a flora unusually rich in species of fungi.

It is natural to question the application of the above facts especially when we account for the abundance of mycelial growth and fructifications for autumn only. Do not the same conditions have a vernal application? Do the results exactly correspond? The answer to the first question is yes, to the second, no. The leafy carpet retards the change of soil temperature both during autumn and in spring, but the retardation in one case while soil temperature is becoming warmer is disadvantageous and in the other when the change is from warm to cold is advantageous. In other words, the autumnal retardation of temperature change makes possible a continued production of fungi, while the vernal retardation delays the production. Consequently we find the first terrestrial fungi appearing at least a month after the vernal equinox, likewise abundant production continues for a month beyond the autumnal equinox.

Many people are disappointed by the absence of fungi during the months April until August, inclusive. The weather is warm and rainfall, especially during spring and early summer, is often sufficient for the growth of these elusive plants. Why are they not everywhere conspicuous, especially in the forests? A few reasons may be proposed, each explaining a different phenomenon.

From the paucity of terrestrial vernal fungi a few facts may be gleaned by direct observation. Fungi which are to be found are in pastures, open woods, and other habitats where sunshine may exert its warming influence. The genera Morchella, Peziza (see fig. 1), Coprinus, Panaeolus, Naucoria, and various field puffballs, although widely separated, make up the collections found during April and May. The warm sunshine has a drying effect in addition to its heat, consequently the arid months arrive almost simultaneously with the proper soil temperature within the forest. Add to these factors the time element required for vegetative growth of a fungus and the presence or absence of fungi during the various seasons becomes reasonable. Yes, but what is this time element? We have always supposed "mushroom growth" to be very rapid, requiring but a few hours, and that any time during the year when a high moisture content and warm temperature prevail, even for a very short time, mushrooms should be everywhere ready for collecting. The answer is: "mushroom growth" refers only to the production of carpophores and takes no account of the two weeks required, under most favorable conditions, for the mycelial growth necessary before our smaller fungi will appear in fruit, or the several weeks required for larger fungi. As evidence of the time element requirement, new data accumulates each year during August and September when, after several weeks of dry weather, rainfall again becomes normal or above normal, yet at least two weeks intervene before some of the smaller terrestrial forms appear, to be followed by medium sized and finally after several weeks by the very large ones. What interpretation may we consider applicable to such evidence? Certainly the accumulation of nutrition within the mycelial network and a widespread growth of the structure in order to contact and contain the supply of nutrition must occur before the dicaryophase condition and its stimulus brings forth rapid production of fructifications. The widespread growth and the large accumulation of nutrition required for larger species is relatively comparable to the extended time required for these plants to come to fruition. It is also true in general that large mycelial structures accompany and produce large fructifications, and comparatively small vegetative structures produce small carpophores. Hence, with the recurrence of rainfall regularly and abundantly following the deadening affect of several arid

weeks, events follow in normal sequence; one or two weeks of rainfall in which no fructifications appear, a week in which small fungi, such as species of Mycena, Collybia, Marasmius, and Coprinus are dominant, followed by succeeding days with new and larger forms gradually coming into and adding to the total number composing the fungal flora.

The continued growth of the vegetative structures of these saprophytes greatly reduces the leafy covering of the soil. Here again a balance is maintained between the amount of moist decaying leaves and the numerosity of fungi. The annual budget of fallen leaves is rapidly becoming an integral part of soil when the time arrives for the new autumnal carpet.

The normal human questions during spring invariably deal with why fungi are so few and far between. Recollections of the autumnal forest densely beset with hundreds of terrestrial fungi has led the usual observer to expect similar growth during the vernal season. The somewhat detailed discussion of ecological factors bearing on these questions serves to make reasonable the contrasting paucity and abundance.

Mosses, lichens and liverworts constitute a living substratum, nestled among and beneath the leaves to invite other entirely different types of fungal communities. Usually somewhat removed from the leafy floor and from the living mosses, liverworts and lichens, grasses grow, their roots and dead leaves giving sustenance for fairy rings of Marasmius oreades (see fig. 2) and Agaricus campestris on pastures and fairways.

An analysis of the interrelationship of the various parts of the substrata brings forth the tremendous importance of fungi. On a single stump, somewhat decayed, one may find six or seven species of fungi, each with its own peculiarities of action, but all functioning to eventually return the wood to the soil. In the growth of fungi chemicals are ecologically more important than for seed plants where physical factors are largely responsible for associational differences.

Diversity of saprophytism and parasitism is illustrated by the presence of Polyporus Schweinitzii always on pine, Mycena vulgaris on pine needles, Marasmius oreades attached to grass roots, Polyporus conchifer (see fig. 3) on elm twigs, Tricholoma transmutans on black oak roots, Polyporus tsugae on living hemlock and Nyctalis asterophora on another fungus, Russula nigricans.

The economic importance of fungi as related to the decay of structural timbers has by some been recognized for three-quarters of a century. In a letter of December 9, 1889, P. H. Dudley wrote to Charles H. Peck, state botanist of New York, calling attention to the loss due to decay of bridge timbers, ties, and the lumber used in building freight cars. He mentioned the prevalence of Lentinus lepideus on the ties of yellow pine (Pinus palustris Mill.) He stated that these were so numerous in main line tracks and so conspicuous during September 1889 as to be noticeable from the trains. "Pilei six to eight inches in diameter were frequent, while four in a cluster of small diameter springing from the same mycelium seemed to be a common mode of growth, this unusually wet season. The resinous matter in yellow pine in its natural state does not seem to check the growth of the fungus." This same fungus reaches ten inches across on the timbers used for construction at the parking area near Tower Falls in Yellowstone National Park. Construction here is mainly of Lodgepole Pine. Dudley further writes that Omphalia campanella Batsch (see fig. 4) was found fruiting on white cedar (Chamaecyparis sphaeroidea Spach) from May until October. White oak timbers frequently showed Fomes applanatus Fr. in fruit while Polyporus versicolor Fr. was very abundant. The absence of fungi in fruit upon ties of chestnut (Castanea) was as striking as its frequency on other woods. "It is a well known fact" he writes, "that chestnut ties last longer where the ground is damp, than where it is dry."

Concerning the presence of Omphalia campanella on the white cedar, one explanation seems sufficient. This fungus may have occupied the timbers for months, spreading vegetatively and causing decay without producing a single fruit; then with the stimulus of decay-chemicals in the substratum added to the presence of a moisture supply came to abundant fruition. The same, to a lesser degree, may be said of Fomes applanatus and Polyporus versicolor. They too are prolific in the growth of mycelium, and show but little tendency

to fruit until the supply of nutrition undergoes a marked chemical change, then, as though signaled by the code of race preservation, the pilei appear. The procedure varies in degree with different fungi, but the story is much the same. Some produce several successive crops for several years while the decaying wood becomes softer and softer in its reduction to soil.

Another interesting observation by Mr. Dudley concerns the abundance and destructiveness of Lenzites sepiaria Fr. Under the station platforms and the planking of the walks, he found its mycelium abundant, generally without fruiting, and follows with the observation: "This has not set men to thinking of better methods for replanking for they carry on the replanking exactly as of old, that is, in the best manner to promote the growth of a new crop of fungi. Consequently in a few years replacement is again necessary. Unseasoned timbers are especially susceptible and during a damp season will show traces of mycelium in two or three weeks. Well seasoned timbers contain inert mycelium if any at all and this remains inactive until moisture reaches it. This again starts decay. Some have suggested painting the timbers to protect them from the mycelium of decay but this proves of no value if moisture and the mycelium are present within, for in the same short period of time decay has weakened the wood and replacement must follow. Users of wood have long considered the fungi as merely accompanying the decay and not its cause, consequently they have done little to preserve the wood or to eliminate the fungi. So small are the spores and so readily disseminated that every crevice in the timber contains many which await the presence of moisture to begin the growth of mycelium and with it the decay of the wood." During a period of fifteen years the old railroad bridge over the north branch of the Chicago River in Harm's woods, west of Evanston, proved a most interesting illustration of these processes. The most prevalent of all was Lenzites sepiaria (see fig. 5) and ninety percent of the decay was attributable to this species alone. Remembering that these timbers were solid twenty years ago and that the trolley cars were then in use, one could with a minimum of time repeatedly visit these timbers and evaluate the destruction caused by the growth of mycelium within the wood.

The final paragraph of Mr. Dudley's letter is interesting: "As an illustration of simple and effective measures, I will give an example: When I was chief engineer of the Valley Railway of Ohio, I built some extensive trestles. This was in 1873. Before doing so I examined a number of trestles near Cleveland, Ohio, built of 10 by 12 or 12 by 12 timber, the life of which did not exceed seven or eight years. In examining them, I found that while the large timbers were sound upon the outside, internally they were all decayed. The small timbers, 6 by 8 used for braces and of the same kind of wood, were sound. The small size enabled them to season in the structure. This was an important fact, so I made all my timbers small, using more of them to give the proper factor of safety. One of these trestles is in use now, 16 years later. In this case, one of the three essential requisites for the growth of fungi was eliminated, namely, moisture in the interior."

Much of the discussion in the letter of Mr. Dudley refers to the decay of timbers but this may not apply to the decay internally of trees by parasitic fungi. Some fungi do perform the double function of saprophytism and parasitism exhibiting ability to thrive on a living or on a dead substratum. It is not unusual to find

PLATE I
Explanation of Plate

1a.—Morchella esculenta. The morel, sometimes called honeycomb mushroom occurs during spring.

1b.—Peziza coccinea (Scarlet Peziza) occurs during April. The inside of the cup is a brilliant scarlet color.

2.—Marasmius oreades. Fairy rings of this species and of Agaricus campestris are found on golf courses and pastures.

3.—Polyporus conchifer prefers to grow on dead and fallen elm branches.

4.—Omphalia campanella. Golden trumpets; with golden yellow caps; a multitude of these rapidly decay a log or stump. Caps ½ inch across.

5.—Lenzites sepiaria lower surface is gilled, but in some specimens is somewhat daedaloid; yellow and brown colors make the plant very attractive; on railroad ties.

6.—Fomes applanatus. Species of the genus Fomes are perennial adding a new layer of pores each year. Many of them are obligate parasites.

7.—Hydnum erinaceum. Hydnums are included among our edible fungi.

8.—Amanita phalloides (Deathcup). This is the most deadly of all to those who look for mushrooms for the table.

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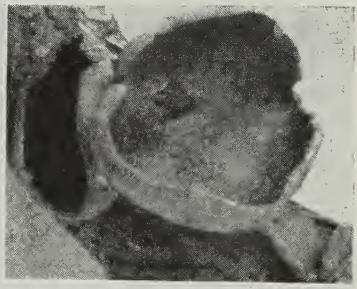

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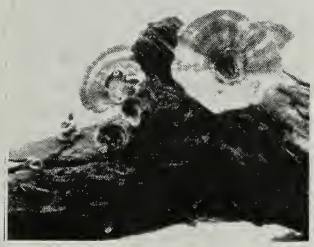

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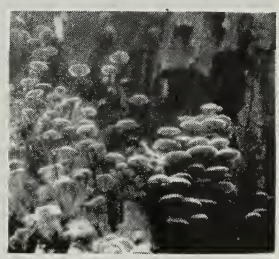

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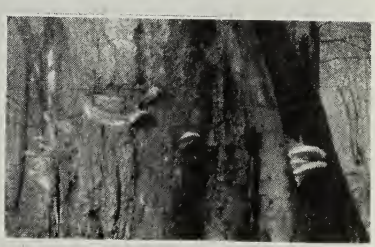

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Polyporus Schweinitzii on the dead trunk of Pinus strobus or on the living trunks or roots of the same species, or to find Polyporus tsugae on either living or dead hemlocks. Because of such latitude of toleration, it is sometimes difficult to formulate laws for determination and prediction as is indicated by the following illustration: On the high point of land bounded by the two streams at the confluence of Turkey Run into Sugar Creek stands a hemlock afflicted for at least twenty years with Polyporus tsugae. The normal expectancy for such a disease includes mycelial growth within the tree until decay has changed greatly the chemical nature of the wood, the storehouse of food for the mycelium, then in the final stage of the life of the tree, the appearance of fructifications. This remarkable tree has all these years been host of a disease, and for at least eighteen years produced on its branches and trunk four or five pilei of Polyporus tsugae, yet the health of the tree has not greatly changed for several years. A few of its branches exhibit internal decay, but always such branches produce pilei of the disease-producing fungus. It is evident in this case that the disease is local in character, that the tree is parasitized in one sector only, the decay-producing mycelial strands follow the grain of the wood upward from its point of entrance, until the tissues of wood divide, some to a branch and some within the tree trunk. Strands then multiply within the branch until decay renders this member an unfit host. When such a condition arises fructifications appear, to scatter the spores on the winds to other hosts.

The destruction of trees in our forest preserves, especially in local areas, furnishes a splendid opportunity for observation and study. A survey of a single forest such as Harm's woods will reveal more than one hundred epixylous species. A few of these are obligate parasites, others fit into a varied classification. Some like Polyporus gilvus show preferment for dead trees and where present on living trees are attached to and deriving nourishment from dead wood. Others exemplified by Fomes connatus derive nourishment from the living wood of the tree trunk. Direct evidence of their presence is withheld from us until a considerable part of the tree is dead when fructifications appear. A third type may be said to live on either dead or living wood. Within this classification may be such as Fomes applanatus, (see fig. 6), usually found on stumps or logs in various stages of decay, but sometimes on the living trunk of Quercus alba. Such obligate parasites as Fomes connatus of maples, Fomes rimosus of Robinia pseudoacacia (black locust), Fomes Everhartii of Quercus, Fomes pinicola of conifers, Fomes pini of pines, Fomes juniperinus of Juniperus Virginiana (red cedar), Fomes fraxineus and Fomes fraxinophilus of Fraxinus (ash), sometimes surprise us by their presence after death has changed the living tissue of the host into decaying wood. These same parasites also sometimes surprise us by their presence on other than the usual host. Fomes pinicola, easily recognized by the presence of red color on younger tissues, is ordinarily expected on pine or other living conifers but sometimes occurs on beech logs. Fomes fraxineus, notoriously a parasite on ash, produces splendid fruits on cottonwood trees along the Des Plaines River near River Forest, west of Chicago. Fomes fulvus does not divide its host genus into species. It grows on any kind of cherry but is not adverse to the other half of the genus made up of wild plums. Fomes fomentarius is found on living deciduous trees but avoids conifers. Fomes ribes prefers bushes to trees, growing on Ribes (gooseberry) or Symphoriocarpus (relatives of the snowberry). On such very large bushes as witch hazel and alder may be found Fomes scutellatus. In Harm's woods where maple is abundant Fomes connatus is prevalent on that tree, and, were you to look no farther, your conclusion would be that this fungus is an obligate parasite. Somewhat rarely in other localities this disease also affects elm and beech. In the forest preserves of Cook County living elms are exceptionally free from parasitism by fungi, but on the dead twigs will almost invariably be found the attractive cup and saucer shaped fructifications of Polyporus conchifer. Had Mr. Dudley who spoke of the absence of fungi on wet chestnut timbers known of later findings, he would have been much surprised to learn that more than 150 different, easily observed fungi could be found on the dead and dying remnant of

that tree. That these are not minute species hidden from the average observer is indicated by the facts that—

29 are of the genus Polyporus
24 are Agarics (gilled mushrooms)
19 are Porias
18 are of the genus Stereum
9 are of the genus Fomes

The remainder are largely resupinate forms of the family Thelephoraceae.

Another contrast with the statements of Mr. Dudley are the observations about the reconstructed village, Lincoln's Salem, Illinois. The timbers used in this village are infiltrated under high pressure with zinc chloride. The effect of this salt on the protoplasmic content of the mycelium is immediate and powerful, causing plasmolysis and sudden death. It seems probable that timbers so treated may endure for several centuries.

In more recent time, an ever increasing use of preservatives adds years to the endurance of structural timbers. The conditions prevalent a century past, when lumber and labor were cheap, occur less frequently in modern times for the best economy encourages building for the years.

We cannot but wonder concerning the details of adjustment for the balance of life. What biotic changes occur within the host and how are these adjustments accomplished? The softer plants which furnish food for man have been carefully observed and studied in order that strains resistant to disease may be selected. Nature carries forward a selective process producing on the one hand a host sufficiently resistant for endurance of the numerous parasites, and on the other hand, parasites strong, but not too strong, in order that their life and their food supply may continue. A parasite attaining its ecological factors in one part of the world, suddenly released in another region may destroy its host before resistance adaptations occur. A single parasite nearly eliminated the American chestnut from our forests. Such life processes can in the medical field be many times exemplified by such examples as susceptibility to tuberculosis, of people who come from south of our border. The parasitic germs in this case find a virgin field for development where growth may be rapid and without host resistance. Application of these principles to our forests helps to establish understandings of why trees may in various stages of decay live on for many years, finally to be killed by secondary parasites which find entrance through wounds made by the original fungal growth.

Speaking of fungi and man invariably causes many people to see but one side of the subject and they properly ask, "How can we know without learning to recognize all the fungi which ones are edible?" Without knowing them as individuals your diet must be considerably restricted. Analysis of the fungal flora of Illinois and the region within one hundred and fifty miles of Chicago shows the following rules applicable. Our most poisonous mushrooms are gilled. All fungi are non-poisonous which grow on wood, except the beautiful Clitocybe illudens, which is a large, bright pumpkin-yellow gilled-mushroom. Among other edible fungi are all puffballs if used before the changes for spore production, that is while white throughout the cross section, all coral mushrooms (Clavaria and Tremellodendron), morels and pezizas, and finally the black fungi of the genus Xylaria, as well as the peculiar ones which appear shaggy with white hair-like aculei, belonging to Hydnaceae (see fig. 7). The very poisonous mushrooms grow on the ground and belong to the genus Amanita (see fig. 8). Other mildly poisonous mushrooms of other genera of the Agaricaceae are terrestrial.

In conclusion, I wish to express the hope that some of these scattered ideas may make future visits of yours to forests, fields and mossy bogs more interesting, and that you will try to recognize some of the numerous plants which you formerly passed by with the remark: "Just another toadstool". It is much more than a toadstool and its very presence in a particular place must arouse a whole chain of ideas. Your conclusions may then arouse other new associations out of which may grow *your* ecology. Fungi whether epixylous or terrestrial fit closely into the scheme of human existence and each has an important place to fill in the total organization of relationships between fungi and man.

MICHAEL S. BEBB, ILLINOIS BOTANIST AND LETTER-WRITER*

Evelyn I. Fernald
Rockford College, Rockford, Ill.

The letters of Michael Schuck Bebb (1833-1895) are of interest not only to the botanists but to the historians of Illinois. In them are recorded the observations of a man with a keen critical mind and with accurate power of observation combined with a deep love for his fellow men and the world about him. Scraps of wit and humor scattered throughout make them easy to read.

Early in life, in 1861, he corresponded and exchanged plants with the Rev. Joseph Blake, a Maine botanist. In one letter, he gives the following description of himself:

"I herewith hand you my photograph—and here just for a dash at something that may help you to guess what manner of man I am—Hoefland says if a man knows not at thirty his purpose in life it is probably because he has none—Alas Poor Yorick, I have but six months left wherein to find my purpose—and 'still it is a fleeting.' But I must not spin out so—western man—born and bred—Massachusetts wife—two children—mix-up (strange as the mixture is) farmer-naturalist-musician—like *tough* reading—radical republican (turned insurrectionist) never made a noise in the world—never tried—don't think I should have succeeded if I had—Father a lawyer and politician—here is the end of my sheet, so I must stop."

In another letter to Blake written December 9, 1864 from Washington, he writes in a more serious vein, as follows:

"I will never be much of a botanist but I can enjoy the dear flowers—and the fellowship of true plant-lovers as keenly as the biggest Dr. Hooker of them all—and I question if even he found more satisfaction in working up *Welwitchia* than have I over my microscope and seeds of *Juncus*—After all perhaps we lose in sentiment and enthusiasm to gain in knowledge and fame without enhancing our enjoyment. It is not best to be such a topping Scientist as to lose one's interest in the common things of the nearest meadow—I mean of course for humble botanists who seek recreation—and the cultivation of mind and heart—rather than to study and scramble to augment their reputations as Naturalists."

He corresponded with practically all of the prominent botanists of his time and in the library of the Gray Herbarium at Cambridge, Massachusetts, letters to Bebb from eighty-seven contemporaries are deposited. Copies of thirty-two of his letters to the Rev. Joseph Blake were obtained from the University of Maine through the courtesy of Professor F. H. Steinmetz after they had been brought to the author's attention by the generous interest of Professor Neil E. Stevens of the University of Illinois and copies of over two hundred letters to Walter Deane and others from the Gray Herbarium of Harvard University through the courtesy of Professor M. L. Fernald.

By reading these letters you can understand how he was able to accomplish so much work of real value at considerable distance from any other botanists. In the following letter to Walter Deane (February 8, 1888 from Rockford, Illinois), he gives us an explanation of his "technique".

"My tailor has always made two pockets on the hips of my pantaloons. I am too old perhaps to acquire new habits making them useful. I carry no revolver and have a time honored place for my handkerchief. But I have just learned what to do with them and I find they are mighty convenient. I pity people that don't know how to use hip pockets. In one I keep a whole bunch of blank tickets. No matter what I am doing, if it pops into my mind to ask some friend a thousand miles off a question, I out with a ticket, make a memorandum of the question and slip it in the other pocket. So now when I sit down to write to you I go over the accumulation and find two which read as follows 'Deane ask to refer to *Salix Cutleri* Tuck Sillim

*Address presented by the then-retiring president of the Academy before the membership at its annual meeting held in Galesburg, Illinois, May 2-3-4, 1940.

Journal 45; 36 what reasons there given for discarding the old name *S. Uva Ursi* Pursh—please copy anything likely to be useful'."

While in Washington during the Civil War, he became acquainted with William M. Canby and some of the pleasure and stimulus he obtained from that relationship is passed on to Blake, December 9, 1863:

"Yes, Mr. Canby has been very successful—I presume he has told you about our trip to New Jersey—and the East shore of Maryland—We got a fine lot of plants—and thanks to many favoring circumstances made satisfactory specimens. To what new plant do you allude —The *Rynchospora* heretofore confounded with *R. alba?*—Your remarks about finding new species are very just—but I try to keep my mind as free from this whole matter as possible—Envious strife and ambition to possess large herbaria—or to add a species or so to the 100,000 already known tends to embitter the life of a naturalist—and to smother the higher enjoyments he might otherwise derive from his studies—Darwin's observations on the dimorphism in *Linum* are worth a whole batch of new species."

In another letter of February 18, 1863 he mentions another significant contact.

"Dr. Torrey is here lecturing at the Smithsonian on 'Flame' gas light &c.—I was talking with him about our *Oaks* and was glad to hear him say that all the Chestnut group must be put back as Micheaux left it—Certainly no *Western* botanist with a clear idea of species would separate *Q. castanea* and *Q. montana*—for I have often gathered *both* from the same tree—the former at the top and the latter from the lower branches!"

His time in Washington was not spent entirely in a botanical way, as is indicated in this account sent to Blake, July 16, 1864:

"The capitol is safe. The 'Pension Office Guards' were regularly mustered into the service of the U. S. for thirty days. The Rebs got wind of the movement and retreated precipitately! Perhaps the advance of the 6th Army Corps may have contributed to the discomfiture of the enemy, but still the Moral effect (?) of 60 valiant quill drivers ordered to Fort Baker to do garrison duty must have been stunning! Well! now that the emergency is past and I have retired from active military life—the mails reopened etc. I have taken to the pen—answered all the letters I had lately received, and getting in the way of it I believe I will keep on and stir up some of my delinquent correspondents beginning with your esteemed self."

A very fine account of Bebb was written by Walter Deane of Milton Academy, Milton, Massachusetts, and published in 1896 in the *Botanical Gazette.* (This also includes a complete list of his publications.) They exchanged letters and specimens and were very close friends. It is singular that they never saw each other. They had arranged to meet each other at the Columbian Exposition in Chicago but missed each other by a few days—a great sorrow to both of them.

When the father of Michael, William Bebb, former governor of Illinois, purchased five thousand acres of land in Winnebago County and in 1850 most of the family and belongings were sent via the Miami canal to Sandusky and thence by the Great Lakes to Chicago and overland to Fountaindale near Seward in Winnebago County, Michael and a brother drove a herd of cattle the four hundred miles. A glimpse of that trip is thus pictured for us:

"How beautiful the rolling prairies were before man's incoming! You never saw an old fashioned prairie "breaking plow"—It was drawn by ten huge oxen and cut a furrow 30 inches across—The soil was cut only about two inches thick and was laid over as smooth and even as the boards of a floor. On the 'land side' stood in all the purity and freshness of its pasture beauty the native vegetation—on the other was a black field with not a vestige of living plant to be seen—such an outfit—and there were thousands of them at work all over the country—would destroy in one hour more beautiful plants than have been collected by all the botanists of the state since the Indians were driven out—A few choice things were left on stony knolls where the stones would dull the *sharp* edge of the breaking plow—or in nooks too irregular in shape to pay for cultivation but even they gave way a few years later to blue grass and cow pasturage—*Troximon* which grew out in the open and upon the richest and sunniest slopes was about the first choice

thing—botanically considered—to be utterly exterminated. I have not seen a plant of it growing in years."

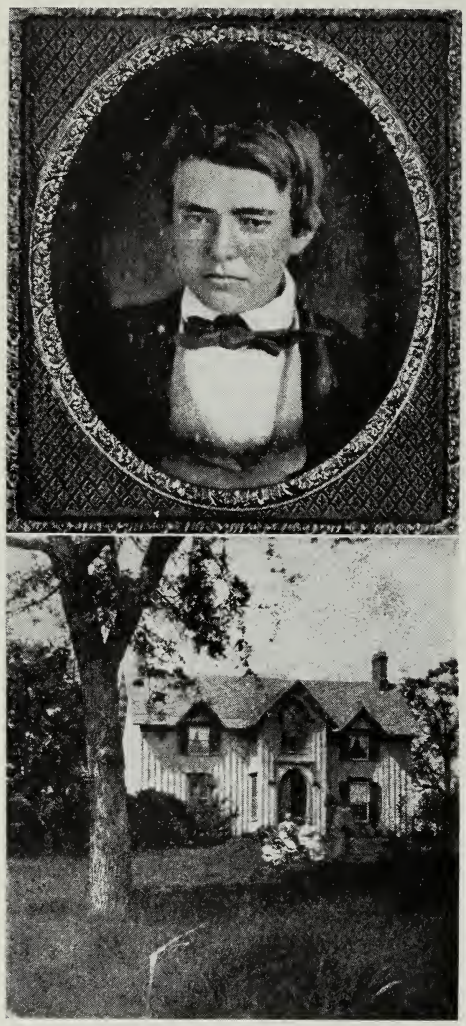

Fig. 1 (above). Michael Schuck Bebb as a boy, copied from an old daguerrotype loaned by A. S. Ruhl of Rockford, Illinois.

Fig. 2 (below). Fountaindale, Illinois, home of M. S. Bebb.

An old daguerrotype given to Mr. Antes Ruhl of Rockford, Illinois, by members of the Bebb family, represents Bebb as he looked at that time (Fig. 1), and a later photograph (Fig. 2) when he was in the prime of early manhood.

On the county line road northwest of Rockford and northwest of Byron, the father built a new home, designed by Downing. How spacious the house and grounds were for those early pioneer days is shown in Figures 3 and 4.

Bebb's interest in plants began when he was very young and persisted throughout his life. When Emerson's *Trees and Shrubs of Massachusetts* was added to the family library in Ohio, it was his first real contact with formal botanical science. At this time, he began to collect plants, and the splendid herbarium of 50,000 sheets now in the Field Museum was built from such a simple foundation. Since he did so much of the work in those days without instruction of trained and experienced botanists, the records on many of the earlier sheets are incomplete. However, by the time (1873) he became interested in *Salix*, he had had sufficient opportunity to know more of the established practices in systematic botany.

From 1857 to 1861 he lived in Odin and Salem and the vicinity of Springfield and at these places made extensive collections. From this locality he went to Washington, D.C., where he remained until 1867. At that time he purchased the old homestead at Fountaindale and made his home there or in Rockford until his death in December 1895.

His studies of the difficult genus *Salix* are more valuable because he made observations of living specimens as well as pressed specimens. In a Salicetum located near a stream at Fountaindale, he planted willows from all over the world. Dr. Hooker sent 1100 cuttings of 175 species from the willows cultivated at Kew and they all lived. When Charles Sprague Sargent was planting willows at the Arnold Arboretum, Bebb sent cuttings and detailed directions for their arrangement and culture. The following is an extract from a letter to Walter Deane written on February 5, 1892:

"I have been fussing over Willows, my usual winter occupation, and have really become quite enthusiastic. It began with work done in a perfunctory way to discharge obligations to others, but in the prosecution of this, certain fresh lines of investigation had to be followed up

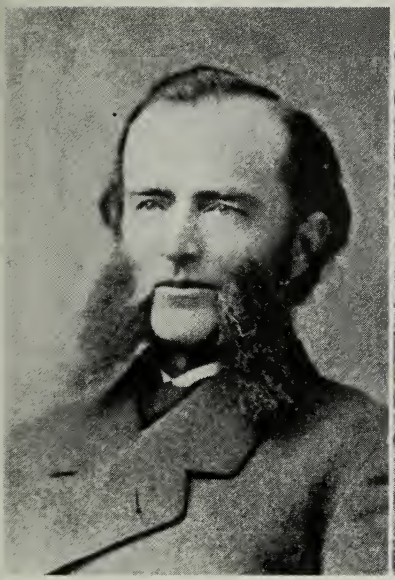

Fig. 3. Michael Schuck Bebb, from a picture loaned by A. S. Ruhl of Rockford, Illinois.

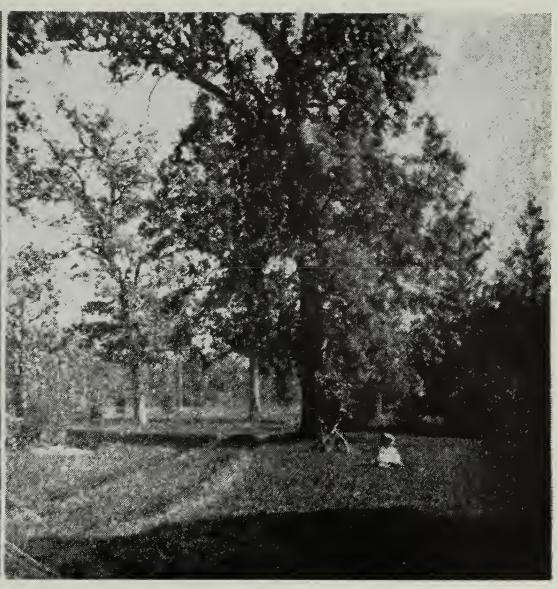

Fig. 4. Fountaindale, Illinois. Home grounds of M. S. Bebb.

and these in the end led to a better understanding of some old questions laid aside as unanswerable. Finding my way Clear I was in fine mood to go on and block out three or four batches of Willow notes for the Gazette. It is only in this way, now, that I can keep up the pleasant illusion that I still belong to the fraternity of working botanists. I envy you your industry and vim, but after all this is only relative. Young Macoun writes that 'his hours are from 8 A. M. till midnight with an hour off for luncheon and dinner' (presumably half an hour for each.) I wrote him that he might work that way in Germany but he had better stop right off or he would get a rap on the head to remind him that the thing couldn't be done in this climate."

Bebb became the world authority on *Salix*. In his early days he devoted some time to *Carex* and corresponded with "that young man Bailey" (Liberty Hyde Bailey).

Among his most important contributions to science are the publication of the Willows of the Peary Auxiliary Expedition in *Bulletin V* of the *Geographical Club of Philadelphia*, of notes and articles in the *Botanical Gazette* and *Garden and Forest*. He selected material from which Mr. Charles E. Faxon drew the willow plates in Sargent's *Silva of North America* and later criticized the sketches. His death in 1895 prevented the completion of the revision of the willows for the *Flora of North America*.

In his lifetime the appearance of northern Illinois underwent many changes and botanizing became more difficult. On January 28, 1891, he wrote to Walter Deane:

"The electric car lines have been extended in several directions one or two miles beyond the city limits (mainly to boom suburban lots) and will afford me facilities in reaching some very desirable botanizing grounds which last summer were beyond my walking ability. One is the hills above the city on the bank of Rock River which last summer I could only visit twice. Now I can go to within a mile by the cars. The other is one upon which I am counting greatly, viz., the right-of-way of the Chicago & Northwestern R. W. which was fenced in thirty years ago and has of course never been cultivated or pastured since.

"All I have the dread is that Bluegrass will have spread in from the farms alongside and smothered out most of the indigenous vegetation."

On May 22, 1894 he wrote to Walter Deane:

"The boys wanted me to join them in an excursion to a favorite collecting ground of theirs on the lake shore near Whitings, Indiana. I was quite as eager as the rest so one morning we took an early train and did not get back to the city till after dark. We had a walk of a mile and a half along the lake shore, after leaving the R.R. station and then turned off into what was expected to be a region of alternate sand dunes and bogs—heavily wooded in some places,—open and sunny in others—aquatics in the water and the plants of hot sand banks a few rods away. Trees for shade —underbrush for seclusion—where we could cook and eat our dinner with a feeling that we were far removed from man's intermeddling—To the very great disgust of my entertainers we discovered that the whole district for miles had been taken hold of by a land improvement company. The bogs had all been drained by deep ditches—discharging into the lake—the trees cut down or pulled up by the roots with some powerful machine—and the whole surface *burned over*."

His whole family was actively interested in his botanical work. An intensive study of the plants of Cook County, Illinois was made by his son Robert, and his son William was a well known naturalist in Illinois and Indiana.

In this study of the life of Michael Schuck Bebb we realize more clearly than ever that in the youthful scientists and in the amateur scientists there is much of immeasurable value which should be conserved.

HORMONE CONTROL OF REPRODUCTION AND SECONDARY SEXUAL CHARACTERS IN FISHES

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AN ABSTRACT

There is great diversity in the reproduction, reproductive habits and in the secondary sexual character of fishes. The various peculiarities in structure and function furnish a rich background for a study of endocrine factors controlling reproduction and the sex accessories.

Sex and sex reversal. Functional protandric hermaphroditism occurs in some fishes (*Sparus*) and many groups furnish instances of non-functional hermaphroditism. In *Xiphophorus helleri* it is reported that males develop from young females by sex reversal. In other cases experiments involving removal of ovaries have sometimes resulted in regeneration of a testis. It is indicated that in some fishes sex is indeterminate, lightly held and easily reversible. It is not surprising, therefore, that gonads are easily modified. Testosterone propionate administered in appropriate doses has caused degeneration of the ovary in *Phoxinus* and several poeciliid fishes and estrogenic hormones have produced a breakdown of the testis or the formation of an ovotestis.

Relation of pituitary hormones to germ cell stimulation and to ovulation. Precocious maturity has been produced in young fishes by implanting the pituitaries of mature fishes in the eye and in other locations. A similar effect has been obtained by grinding pituitaries and injecting them into the peritoneal cavity. Gonadotropic hormones from mammalian sources have also been found to be effective in producing early maturity in fishes. In general, a low degree of group specificity is indicated in the gonadotropic response.

Ovulation occurs in numerous species of fishes when pituitary extracts, ground pituitaries or whole glands are injected or placed in the peritoneal cavities of fishes of the same species. The pituitary hormone of one species is often found to be effective in other species of the same general group but ineffective when administered to a species of a widely separated group. For example, the pituitaries of teleost fishes have been found to be ineffective in cyclostomes.

Hypophysectomy when performed upon a fish undergoing ovulation inhibits completion of the process but ovulation is resumed when pituitary substance is injected into the hypophysectomised fish.

Secondary sex characters. It is convenient to divide secondary sex characters of fishes into two groups. The first includes temporary characters or structures which appear normally only during the breeding season. Pearl organs, nuptial coloration, the mucous glands of the kidneys of the Stickleback and the elongated ovipositor of the Bitterling belong to this group. The second group consists of permanent organs developed at the onset of sexual maturity and include the gonopodia of various fishes in which internal fertilization occurs.

The appearance of temporary secondary sexual characters is inhibited by castration and it is assumed that the characters are controlled at least in part by hormones secreted by the gonads. A better demonstration of the control of secondary sexual characters by estrogenis and androgenic hormones has been furnished by experimentation on the gonopodium of poeciliid fishes. It has been shown that castration inhibits gonopodial development but development is resumed if there is testicular regeneration. A piece of regenerated testis about one fiftieth the size of a normal mature testis furnishes sufficient hormone for the complete development of the gonopodium. Smaller amounts of testicular tissue furnish hormone enough only for the earlier stages of development. When

completely castrated males are treated with an androgenic hormone (ethinyl testosterone) gonopodial development is resumed. When females are treated with ethinyl testosterone the anal fin undergoes a metamorphosis and produces a gonopodium which is atypical but contains the specific characters of the male gonopodium. It has been found that a very dilute solution of the hormone, I mg of the hormone to 110000 cc of water, will produce the earliest stages of metamorphosis but that increasingly greater concentrations are required for the development of each succeeding stage. Reaction to the hormone takes place more rapidly in younger specimens and at higher temperatures. When development has ceased because the temperature level is too low or the concentration of hormone is below that which is required further development may be induced either by raising the temperature or by increasing the concentration of the hormone. It is inferred that in the normal development of the male gonopodium very small quantities of hormone are required to initiate development but that increasing amounts are required for each succeeding stage.

PATTERNS OF NEGRO MUSIC

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The study of musical forms can make an important contribution to an understanding of the nature of human civilization, its processes of change, and the historical relationships between various bodies of custom. That the value of this contribution has been thus far but little recognized either by students of human civilization or by musicologists is not strange, since each field is sufficiently broad to demand the entire attention of specialists. The student of comparative culture must be prepared to deal with the habits of peoples whose modes of behavior differ as widely as do those of Eskimos and South Sea Islanders, of Zulus and aboriginal Australians. The musicologist, also, even though he may restrict his research to problems in the field of western European and American music, must utilize techniques so specialized that little time remains to him for the consideration of materials outside his specialty.

We may thus ask at the outset how the comparative study of music can contribute to an understanding of the processes of human civilization; or, conversely, how a knowledge of these processes helps the investigator concerned with understanding the derivation and significance of a particular musical style.

To answer the first question, it must be recognized that music, as a part of any given body of tradition, can be studied like any other aspect of custom. But the peculiar value of studying music for this purpose is that, even more than other aspects of culture, its patterns tend to lodge on the unconscious level. Especially as regards the processes of change, it seems to manifest that phenomenon which, in the field of linguists has been termed "drift." This implies an almost imperceptible, but consistent and steady change as a result of the continuous introduction of many small elements, all of which are in accord with the underlying structure of the accepted musical style. The cumulative result is that this process eventuates in something which, though differing from the earlier form, is still recognizably related to it.

This process is to be seen, for instance, in the changes that, over the generations, have taken place in style of European folk music and, in more recent times, in that of our more sophisticated musical forms. Each generation, we find, has had its "modern" music, to be protested against by those devoted to an earlier convention. Yet each new step toward "modernism" has been shown to consist of nothing more than the utilization of intervals which represent the next series of overtones to the combinations already accepted. The point is that this process has gone on within the framework of our polyphonic patterns of music which emphasize harmony, patterns that were established when unison singing gave way to two-part melodies, and later, in the Middle Ages, much against the edicts of the Church, the major triad was completed by the addition of a third element.

For the musicologist, an understanding of the wider significance of changes of this sort in our own culture, and the variations in tonal and rhythmic patterns that exist outside our own civilization, afford a perspective that is not only useful to any investigator of human behavior, but in this particular field materially broadens the basis of his approach to his specific concerns. The very techniques that are employed in analyzing foreign musical idioms are, from this point of view, revealing. It was not until a generation ago that the musical significance was realized of the fact that in our society, music is more intimately related to the playing of instruments of fixed pitch than in any other. Today the importance of the piano, with its rigid tonal system, in conditioning our musical reactions is recognized as paramount, not only in

shaping the way in which we express ourselves musically, but the way in which we hear music. It is recognized, of course, that the particular scale we employ is a convention arbitrarily selected from subtly differing tonal values that have an infinite range; that, for example, whole tone scales, or pentatonic scales can give material quite as adequate for the making of musical style as the chromatic system prevailing in our music. Yet the fact that within the limits set by our scale system we regard true pitch as so important, sets us off from folk who do not base their music on mechanically tuned instruments; among such people, for example, a reaction of distaste such as the trained musician in our culture feels when a singer

Fig. 1. Drummers and dancers in the market-place of Kano, Nigeria (British West Africa).

Fig. 2. Members of a cooperative society singing to give rhythm to the hoe-strckes of those working. Dahomey, French West Africa.

flats a note is, for example, unknown. A given tone has only a more or less constant value, and even a quarter-tone deviation causes no discomfort, if, indeed, it does not go unrecognized.

The comparative musicologist, however, will realize that with casual regard for true pitch may go a far greater sensitiveness to rhythm than is the case among ourselves, where in all but the most sophisticated "modern" compositions, and in certain forms of dance music, rhythm is subsidiary, and rarely falls outside the limits of the 4/4 or 3/4 patterns, or some variant on these. The difficulties which many persons in our culture experience in beating out a 5/4 measure is an example of this. For such persons, to master a simple South African piece on the marimba which requires the player to follow a 4/4 beat in the left hand, and a 9/4 in the right—with a rhythmic consonance every 36 beats, is well-nigh impossible.

For the musician, then, to understand that the idiom of his own culture is merely one of an almost infinite variety is of considerable value; a further understanding of the significance of this fact in terms of the techniques employed in recording and analyzing foreign idioms is equally important. As in all scholarly research, to attain the greatest precision and accuracy is essential, and in the study of a strange music, this can be achieved only by the use of recording apparatus. Because of early conditionings, the ear of a person in any culture is so trained that one who attempts to study differing styles soon learns that he cannot trust himself to write down the music he hears, however facile he may be. Having collected his data on cylinders or disks, he can, however, later in his laboratory, with the aid of tuning fork and metronome, transcribe what has been brought from the field. Here, without distraction, he can analyze prevalent scale systems, record the complexities of rhythm, indicate the extent of individual variation in singing and, should he have sound films to work with, attempt to assess such intangibles as singing style and motor behavior while singing.

No body of music can better document the advantage to be gained, both by the social scientist and the musicologist, from research in the field of comparative musicology, than that of the Negro peoples of Africa and the New World.

For here are to be found patterns which, because of the historical relationships involved, have certain broad similarities that reflect the contacts between peoples of Africa and the Negro New World, and at the same time reflect the local developments that have occurred in the various areas involved. Negro Africa, south of the Sahara, comprehends thousands of tribes, among all of whom music plays an important rôle in the daily life and the ceremonial round. The Negro slaves who were brought to the New World, deriving principally from West Africa and the Congo, brought their music with them, not only to the United States, but to the Caribbean Islands, Central America and the northern tier of South American countries, the Guianas, and Brazil. And in all these areas Negro music to some extent reflects this African background. In essence, this forms the fundamental basis for the overlay of European characteristics which, differing in terms of the contacts of these people with Spanish or Brazilian or French or Dutch or English musical styles, and the intensity of these contacts, gives to the musical expression of each local group its special flavor.

The principal characteristics which mark off the underlying pattern of Negro music may be broadly described. The convention whereby the statement of a theme by a leader is repeated by a chorus, or a choral phrase is balanced as a refrain against a longer melodic line sung by the soloist, is universal. This has been commented on by all who have heard Negroes sing in Africa or elsewhere, and is to be found in spirituals and work songs in the United States as well as in various kinds of melodies heard in the West Indies and South America. An intimate and often intricate relationship between the melody and its accompanying rhythm—carried on by drums, rattles, sticks beaten one against the other, hand-clapping or short non-musical cries—is also ubiquitous. So prominent is the element of rhythm in Negro music that this music is ordinarily conceived as relegating its melodic line to second place, though this concept has only partial validity. For as is demonstrated by the songs sung by choruses of chiefs' wives in Dahomey, West Africa, on the occasion of rites for the royal ancestral cult, or by some of the Shango cult songs from Trinidad, British West Indies, or by some of the Brazilian Negro melodies, a long and complex melodic line is by no means unknown in Negro songs. Yet the need to ornament an underlying rhythmic structure is fundamental, and when Negro music as a whole is considered, this trait must receive close attention.

The phonograph records played in connection with this discussion in illustrating the characteristics of Negro mentioned above, and documenting the unity of Negro musical style, bear out the theoretical and methodological points with which this discussion opened. It is evident, when these melodies and rhythms from South Africa, from the Congo and West Africa, from Brazil, Trinidad, and Haiti, are heard, that the derivation of the music sung and played by the Negroes of this country will become apparent. At the same time, when the differences between the musical style of these various areas are noted, it will be remarked how these various musical conventions, regarded as cultural patternings, throw light on what has happened to aboriginal Negro musical endowment in contact with various European cultures. The Brazilian songs, it will be noticed, show a strong Iberian overlay, through which African stylistic values manifest themselves in terms of the complex rhythms of the percussion instruments, and in the prevalence of the leader-and-chorus convention. It will be noticed in the Trinidad recording of "Jesus, Lover of My Soul" how, using a "Sankey"—a Sankey and Moody hymn—the thematic material has been so reworked in terms of African conventions that they finally take a form far removed from the slow stately measures of the original—a form, indeed, that is essentially the form of the "swing" rhythms that United States Negroes have introduced into the secular dance melodies popular today among all groups in this country.

These records are the following; unfortunately, here only tribe or area represented, type of song, title, and in the case of commercial discs, the company manufacturing the record, and its number, can be given:

Africa

South Africa

1.	Zulu: Nkonto Ka Tshaka	Gallo (Pty.) Ltd., Johannesburg.
2.	Zulu: Malombo	South Africa, No. G. E. 86

Congo

3.	Bahutu: Chant and Dance	Denis-Roosevelt Expedition, No. 10.
4.	Babira: Songs	Reeves Studios, Inc., New York City Same, No. 2
5.	Manbetu: Songs	Same, No. 1
6.	Congo Dialect Song: Iduba	British Zonophone Co., London. No. E. Z. 439

West Africa

7.	Yoruba: Igi Da Pa Ele Po	Zonophone No. E. Z. 305
8.	Yoruba: Oyibo Sewun Ti Oto	Zonophone No. E. Z. 549
9.	Yoruba: Tani Nawa Oni Baba	Zonophone No. E. Z. 426
10.	Fanti: Kwesi Kadagyi	Zonophone No. E. Z. 560
11.	Fanti: Nsamo Pom	Zonophone No. E. Z. 475

New World

Brazil

12.	Macumba: No Fundo Do Mar	Victor (Brazil) No. 34158
13.	Macumba: Caboclo do Matto	
14.	Batuque: Babão Miloquê	Victor (Brazil) No. 33253-A
15.	Jongo: São Benedicto é Oro Só	Victor (Brazil) No. 33380-A

Haiti

16.	Vodun song: Ibo Lélé	General Records, New York,
17.	Vodun song: Joué Kanga Joué	No. 5001
18.	Vodun song: Moundongue yè yè	General Records, No. 5002 B
19.	Vodun song: Ciyè Ciyè 'ti Bobine Carrè	General Records, No. 5003 B

Trinidad

(Note: All Trinidad recordings were made in the field by M. J. Herskovits, during the Northwestern University Expedition of 1939.)

20.	Bele song: Me no well-o	No. 65 b
21.	Bele song: Chamber po', Chamber po' Lady	No. 31 a
22.	Bongo song: Killin' Peter Agent	No. 70 a
23.	Bongo song: Dolaido	No. 79 a
24.	Bongo song: I wan' a Pretty Woman	No. 47 b
25.	Spiritual: Our Father	No. 31
26.	Spiritual: 'Rasslin' Jacob	
27.	Baptist Shout: Jesus, Lover of My Soul	No. 58 b
28.	Shango cult song: Yemanja	No. 96 b
29.	Shango cult song for Osho: Menia, Menia	No. 97 a
30.	Shango cult song: Adjadja-e	No. 98 a

This music has considerable point for the current controversy as to the derivations of American Negro songs, particularly the spirituals. The discussion of this matter goes back to about thirty years ago, when H. E. Krebhiel published his volume "Afro-American Folk Songs," in which he attempted to show that the spirituals were essentially African. His hypothesis was generally accepted, until a re-examination by various students some ten or fifteen years ago noted striking similarities between the spirituals, and hymns—in some cases what may be called folk hymns—of the white people of this country, in both melodies and words. Since then, scholars have tended to align themselves on one side or the other, though, curiously enough, in no case has anyone who has written on the matter had any large acquaintance with African music, even, indeed, as large an acquaintance as would be gained by hearing the series of records played in connection with the presentation of this paper.

To a person acquainted with the range of local style included in such a collection as is represented in the records listed above, this discussion must seem pointless, and somewhat unrealistic. For one thing, the problem of origins goes beyond the spirituals, involving also the roots from which such other forms of Negro music as work-songs, songs of recrimination, "blues" and other dance forms have been derived. As far as the spirituals are concerned, a realistic approach would seem to indicate a conclusion that their present form represents responses on the part of Negroes both to the music of the Whites heard by them in this country, and a reworking of this material in terms of the aboriginal stylistic patterns of their ancestral African forms. In stating this, the renderings of the spirituals written for concert presentation are not meant, for though they may be beautiful, they are nonetheless artificial versions, translated into current majority patterns of music. The living spirituals, sung by devotees affiliated with groups whose worship is outside the commonly accepted conventions of American religious behavior, sung in lowly Negro churches, in places of worship such as are colloquially known as store-front churches, and the like, are quite different. For in these humbler gatherings, the "swing" element, so important in secular Negro song, also predominates in the sacred songs, and the synthesis of both African and European elements is plainly to be discerned. Jazz and swing are rarely taken into account in discussions of the derivations of Negro music. Yet it is not an accident that the exponents of these musical styles who are most effective in their presentations are Negroes. The importance of rhythm in this dance music, the improvisation that characterizes its playing, the repetition of thematic material are all distinctly African. It is more than chance that this music is so closely associated with the dance, for the relationship of song and rhythm to dance in Africa and Negro America is fundamental.

In considering some of the problems present in the study of Negro music, therefore, it has been indicated how advantageously certain controversial issues can be approached through the use of these materials. In the case of a question which is of great importance for this country at the present time, that of the derivations of Negro custom in general and the carry-over of Africanisms in all aspects of Negro behavior, it has been shown how an approach of this kind affords definite data that throw light on the mechanisms which can then be considered in terms of their applicability to the change in other aspects of custom resulting from the contact of Whites and Negroes. From the larger point of view, also, it is to be seen how the study of comparative musicology makes for an understanding of the fact that the musical style of our own culture is but one of an infinite number of possible varieties of musical expression, and that the student who approaches our music with this fact in mind will find new values in it which arise from a deeper realization of its significance as a part of the musical resources of humanity as a whole. Finally, as concerns the student of society, it is apparent that music, objectively recorded and competently analyzed, can offer effective guides to an understanding of the mechanisms of cultural change, and of the historic relationship between cultures as they exist over the earth at the present day.

A SUMMARY OF OUR KNOWLEDGE OF ENDOCRINE MECHANISMS IN CRUSTACEANS*

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Definite demonstration of the presence of an endocrine mechanism in invertebrates is of quite recent origin, extending back not more than about fifteen years. Biologists have, nevertheless, suspected for several decades that such mechanisms existed among these lower animals. When one considered the fact that almost every basic physiological mechanism found in the Vertebrata appeared to have its counterpart somewhere among the Invertebrata it was not unreasonable to presume that hormonal coordinatory mechanisms were operative there just as in the Vertebrata. Many problems in invertebrate physiology which remained quite refractory to solution solely in terms of nervous coordination recently have yielded much ground in terms of endocrine coordination. A number of general reviews of the subject have been prepared, namely Koller, 1929, Hanström, 1937a, von der Wense, 1937, Koller, 1938, Lelu, 1938, Hanström, 1939, and others are in preparation.

The first invertebrate group to provide unequivocal evidence for the possession of an endocrine mechanism was the Crustacea (Perkins, 1928). And today we probably have as large a body of information concerning crustacean endocrine physiology as we have for any other invertebrate group, with the possible exception of the Insecta. Even in these best known groups, however, our knowledge is still very rudimentary and sketchy. One who is primarily familiar with the relatively refined and detailed state of the field of mammalian endocrinology must look with patience and understanding upon this new field which is only now concerned with the rough determination of hormonally controlled processes, and the sources of the hormones involved. Furthermore, the investigation of invertebrate endocrinology is rendered somewhat difficult by the small size of most of the animals which must be investigated and also due to the general phylogenetic tendency toward decrease in structural differentiation and segregation of organs or parts of organs concerned with specific functions. This last tendency, of couse, culminates in the Protozoa whose total structural bases of functions are confined within the limits of a single cell membrane.

It is obviously impossible within the twenty minutes allotted for this report to cover even in outline the whole of our knowledge of invertebrate hormonal mechanisms. The literature includes more than 1000 articles. Nor is there even time to discuss adequately the experimental evidence upon which our knowledge of a single endocrine gland (i. e. the insect corpora allata or crustacean sinus gland) is based. Instead, a middle pathway has been selected in which there will be an attempt to present a brief and summary account of our present picture of crustacean endocrines, their sources, and the functions which have been assigned to them. It is hoped that too much has not been attempted.

The Eyestalks and the Sinus Glands.— For many years it has been known that many higher crustaceans macroscopically blanch or darken their integument to correspond with the shade of the background upon which they come to lie. These color changes are principally the result of migrations of differently colored pigments within the bodies of highly branched integumentary cells called chromatophores. Any pigment which is dispersed into the branches and ultimate twigs of a chromatophore imparts its color to the general appearance of the animal; conversely, any pigment which is concentrated into a minute knot in the chromatophore center has little or no influence upon the gross

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coloration. By appropriate differential migrations of pigments of several colors a number of crustaceans may simulate more or less perfectly the tints of variously colored backgrounds. Many operative techniques involving cutting of nerves and consequent denervation of areas of the body of crustaceans have failed to interfere with the normal responses of the chromatophores concerned. Thus there is evidently no direct nervous control of these cells. Koller (1925, 1927) gave us evidence from blood transfusions that a blood-borne agent was responsible for certain of these chromatophore responses in the shrimp, Crago. Shortly thereafter, Perkins (1928) discovered that water extracts of the eyestalks of the shrimp, Palaemonetes, possessed the ability to concentrate dispersed red pigment strongly, thus blanching this animal. Extract of no other part of the body appeared to do this. Koller (1928) confirmed the presence in the eyestalks of Crago and of Leander of such a chromatophorotropic substance which produced strong concentration of their dark pigments. Koller further demonstrated that the eyestalk substance was not species-specific, but that eyestalk extract of Leander was effective upon Crago chromatophores and Crago eyestalk extract was effective upon Leander chromatophores.

During the following few years Kropp and Perkins (1933) tested many stalk-eyed crustaceans and discovered that all possessed such a substance in their eyestalks. Therefore this eyetalk substance which effected blanching of dark shrimp was of quite general occurrence.

In 1935 Carlson, and later in the same year Abramowitz, showed us that, contrary to the condition obtaining in shrimp, eyestalk extract of crustaceans produced dispersion of concentrated black pigment in the crabs, Uca and Portunus.

Meanwhile, Brown (1935b) had been examining in much detail the structure and responses of the chromatophore system of the shrimp, Palaemonetes. After learning that this animal possessed four pigmentary types (red, yellow, white and blue), all of which were able to react relatively independently of one another (even in a denervated area) when the animal was placed upon backgrounds, he concluded that the existence of at least four hormones was indicated to account for this complex behavior. This conclusion was unnecessary, as has been pointed out by Parker (1940), since three hormones, A, B and C, can be seen to yield seven combinations which could conceivably have as many qualitatively different actions on the chromatophore system. As a matter of fact, the absence of all three would provide an eighth possibility.

Abramowitz (1937a) believed that all of the responses of the chromatophore systems which had been described might be explained in terms of one principle which he called ESH (eyestalk hormone). He believed that differences in the effectors together with differing threshold responses would account for the complicated responses of the chromatophore systems. This theory he called the "unitary theory" in contrast to the "multiple theory" proposed by Brown. However, even on the basis of his own theory, Abramowitz failed to explain satisfactorily the complex behavior found in Palaemonetes (Brown, 1934-1935a) or Portunus (Abramowitz, 1935). Despite this, Abramowitz continued to uphold the theory that a single hormone was present in the eyestalk, and subsequently set about assaying and attempting to purify it (Abramowitz, 1937b).

Hanström (1933, 1934) had earlier described two gland-like bodies in the eyestalk of crustaceans, the blood gland and the X-organ (Dohrn, 1906). In 1935, by dividing eyestalks of various crustaceans transversely into thirds, he found a correlation between that third possessing the blood gland (later called the sinus gland) and that possessing the chromatophorotropic activity. He concluded upon this circumstantial evidence that the sinus gland was the source of the principle. This conclusion was confirmed by Brown (1940) who made extracts of isolated sinus glands and compared their activity both quantitatively and qualitatively with extracts of both whole and sinus glandless stalks. The sinus gland appeared to be the only eyestalk gland concerned in the reactions examined.

A year following the discovery of the chromatophorotropic activity of the eyestalk, Koller (1930) brought forth evidence that the eyestalk hormone was concerned with calcium metabolism in Crago, since eyestalkless animals pos-

sessed less calcium in their molted exoskeletons than did normal ones.

Another function ascribed to an endocrine originating in the eyestalks is the control of retinal pigment migration. The retinal pigments are located within the ommatidial complex and are typically classifiable into three groups: (1) the proximal retinal pigment, (2) the distal retinal pigment, which are light-absorbing melanins, and (3) the white reflecting pigment, guanin. These three pigments assume different positions in the compound eye in light and in darkness. In many crustaceans these pigments continue to show rhythmical diurnal movements even when maintained under constant conditions of light. Kleinholz (1936) brought forth clear evidence for endocrine control of certain of these pigments. Injection of eyestalk extract into a dark-adapted Palaeomonetes caused the distal retinal absorbing pigment and the white-reflecting pigment to assume the condition for light adaptation. The proximal retinal pigment, curiously enough, was unaffected. In 1938 Kleinholz concluded as did Hanström (1937b) that the hormone involved in this capacity must be different from those involved in integumentary pigment control since the retinal pigment activity was apparently quite independent of that of the integumentary chromatophores.

Welsh (1937) believed he had evidence that a principle originating in the eyestalk produced acceleration of heart rate in Cambarus, but during the following year performed other experiments which suggested that the effect was due to acetylcholine which could be extracted from crustacean nerve tissue quite generally. Scudamore (1941) however, presents evidence to prove that the sinus gland produces a principle which accelerates heart rate in the normal animal.

Another line of research has led to the conclusion that a hormone arising in the eyestalk is concerned with the control of molt and consequently is a factor influencing growth. Brown and Cunningham (1939) were able to accelerate molting rate by eyestalk extirpation and conversely were able to compensate partially for the effect of eyestalk removal by implanting sinus glands into the abdomens of the eyestalkless animals. Confirmation of molt acceleration following eyestalkectomy was obtained by Smith (1940), Abramowitz and Abramowitz (1940), and by Kleinholz (1940). Abramowitz and Abramowitz also showed a growth rate greater than normal. Unfortunately none of these later workers attempted implantation of eyestalk tissue, or extract injections, to determine whether the effects were actually the result of a hormone deficiency.

Brown (1938), Brown and Cunningham (1939) and Smith (1940) reported greatly decreased viability of Cambarus following eyestalk removal. The reason for this effect is still far from clear.

Finally, of the many functions ascribed to an eyestalk hormone, we might mention the control of blood sugar concentration (Welsh, 1941). Injection of eyestalk extract results in a sudden modification in blood sugar.

With all of the more or less well demonstrated functions of hormones arising in the eyestalks of crustaceans it appears highly improbable that we are dealing here with a simple gland secreting a single principle. This is particularly evident when we recall, for instance, the demonstrated relative independence of the four pigments of Palaemonetes in normal color change, and the independent behavior of the retinal pigments with respect to the integumentary pigments. It appears far more likely that a number of hormones are present.

The first successful attempt to demonstrate more than one active fraction from sinus gland was made by Brown and Scudamore (1940). They found that when dried sinus glands were extracted with 100 per cent ethyl alcohol a fraction entered the alcohol which showed qualitatively different chromatophorotropic properties from the fraction which was alcohol insoluble. Whereas extract of whole sinus gland strongly concentrated red pigment of Palaemonetes and strongly dispersed black pigment of Uca, the alcohol soluble fraction had almost no effect upon Uca black pigment while it had a strong effect upon Palaemonetes red. On the other hand, the alcohol insoluble fraction had a very strong dispersing action on Uca black but had a relatively weaker effect upon Palaemonetes red. Thus these results obviously could not be explained in terms of different concentrations of a single substance in the two fractions. A number of crabs and shrimp were examined and all

showed the presence of these two principles in varying proportions.

Central Nervous Organs.—It gradually became evident to certain of those working with crustacean chromatophores that the eyestalk was not the sole source of chromatophorotropic hormones. Eyestalkless animals showed chromatophore fluctuations and responses which could not be explained in other terms than variations in the concentrations of controlling hormones in the blood of these eyestalkless forms. Heterologous stimulation of the eyestubs of eyestalkless forms resulted in definite though transitory chromatophore responses by way of blood-borne agents. Brown (1933, 1935b) and Hosoi (1934) discovered that extracts of the nervous system of certain shrimp possessed chromatophorotropic activities. Kleinholz (1936) and Abramowitz (1937a) believed these effects were probably due to storage of an eyestalk principle in the central nervous organs. This explanation is quite untenable especially since the properties of this principle or complex of princiles has been shown to be unlike eyestalk extract. even affecting certain chromatophores, the guanophores, in quite the reverse manner.

It appears highly likely that certain diurnal chromatophore changes which are known to occur in eyestalkless Uca and Cambarus result from a periodic liberation of such a principle from the nervous system.

The Rostral Organ (Schwarz-Organ).—Koller (1928), after confirming the discovery of Perkins that the eyestalks yielded an extract which would produce rapid blanching of the shrimp, reported that an antagonistic substance originated in the rostral region of Crago. Injection of extract of this region resulted in a darkening of the shrimps. The source of this hormone Koller named the "Schwarz-organ". With the exception of Beauvallet and Veil (1934) no one has been able to confirm the presence of such a rostral organ in shrimp, even in Crago. The matter appeared conclusively settled by the work of Kleinholz (1938) who carefully reinvestigated Crago obtained at the same place as Koller's animals. Kleinholz found no evidence for a schwarz-organ.

Commissural Ganglia.—The shrimp, Crago, possesses a very complex pigmentary system containing at least eight physiologically or morphologically different pigmentary types (Brown and Wulff, 1941). Despite the fact that this shrimp had been one of those most frequently investigated, yet there seemed to exist a very inadequate picture of the mechanism of pigmentary control. During the summer of 1939, Brown and Ederstrom (1940) reinvestigated this species. The investigation was commenced since the apparent final elimination of the "schwarz-organ" by Kleinholz left certain responses of eyestalkless animals (Brown, 1939) quite without explanation. If the "schwarz-organ" of Koller was non-existent then another source of a pigment dispersing agent seemed essential to explaining certain observations. Brown and Ederstrom noticed that within an hour after the removal of the eyestalks of Crago the telson and uropods become completely blanched and normally remain so. Stimulation of the eyestubs or other harsh stimulation resulted in a rapid darkening of the "tail"; this darkening persisted for one half to one hour and then disappeared. This was demonstrated to result from the activity of a blood-borne agent. A thorough survey of body tissues finally resulted in localizing the source of the hormone involved in the ganglia upon the circumoesophageal commissures. This principle was shown to be present in greater quantity in the commissures of white adapted animals than of black adapted ones. Thus it was demonstrated to be concerned with normal color changes in this animal.

Further investigation of the control of Crago chromatophores by Brown and Wulff (1941) led to the clear conclusion that in Crago the commissural ganglia are apparently as important in the hormonally controlled color changes of this form as are the much more publicized sinus glands. A number of pigments within the integumentary chromatophores are affected in opposite directions by extracts from the two sources. Other pigments are affected in the same direction by the two, but to differing degrees.

Evidence has been obtained demonstrating that the commissural ganglia contain more than a single chromatophorotropic principle. Ethyl alcohol extracts of the ganglia yield a fraction which is very active in blanching the

trunk of Crago. The "tail-darkening" principle of the ganglia is alcohol insoluble and remains in the residue after brief alcohol extraction. The alcohol soluble fraction appears at the present time to be similar to the principle which is found in all of the central nervous organs of Crustacea.

It is interesting, from the comparative standpoint, that the "Crago-tail-darkening principle" has been found in the commissural ganglia of the other shrimp but not of the crabs examined. Furthermore, a sinus gland principle which antagonizes the action of the commissural ganglia in tail darkening is found in the sinus glands of the shrimps but not of the crabs examined. This appears to be one of the first bits of evidence (see also Kleinholz, 1936) that the endocrine complex is not uniform throughout even the decapod crustaceans.

The Gonads.—Despite the fact that the earliest suspected endocrine activity within crustaceans was probably respecting a hormone influencing the development and maintenance of certain secondary sexual characteristics, yet this is still today not adequately established. The early suspicions were based upon many observations that when a male crab was castrated through parasitization by a rhizocephalan such as Sacculina there was a strong tendency for the animal to take on the external characteristics of the female sex. One of the more popular of the interpretations of this phenomenon was that the animal, as a result of the castration, was deprived of the source of a male sex hormone. These results may, however, be equally well interpreted in terms of modification of the general metabolism, or of specific metabolic processes by the activities of the parasite. These modifications might secondarily influence the secondary sexual characteristics.

Somewhat better evidence for the hormonal activities of crustacean gonads has come from such experiments as those of Haemmerli-Boveri (1926) working with Asellus and Callan (1940) working with Leander. These authors report that destruction of the ovaries by X-radiation results in failure of development in the case of certain female external characteristics concerned with incubation of the developing eggs.

The sum of all the innumerable reports on the subject of determination of the secondary sex characteristics in Crustacea leaves one with the general impression that sex hormones are actually operative, but with little further idea as to the exact site of their formation or the extent of their action.

Definite demonstration of the presence of hormones concerned with the development of secondary and accessory sexual characteristics in crustaceans must be dependent upon the results of surgical removal of the hormone source and upon the results of effects of extracts or implants of this tissue source.

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THE ENDOCRINE FUNCTIONS OF THE MAMMALIAN OVARY*

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The complete expression of sexuality in the female involves the secretion of female sex hormones, ovulation, copulation and the birth of young. The internal secretions of the ovary regulate the sex accessories, the secondary sex characters and the mating reactions. Numerous factors in the external environment are known to influence the cyclicity of the female tract and it is probable that most of these effects are mediated by means of neuro-endocrine mechanisms. Not all of the genetic, endocrine, neural and nutritional phenomena involved in the control of ovarian functions have been elucidated, though substantial progress has been made in this direction during the last few decades. In natural environments there is a basic tendency for females to permit copulations only during recurrent periods when the best opportunities prevail in the female tract for the union of spermatozoa and eggs and for the differentiation of the zygotes.

In newborn mammals a large number of primary follicles are identifiable in the ovaries and, in certain species at least, there is evidence that this number is augmented by proliferations from the germinal epithelium during postnatal life. Only a small proportion of the original follicles ever complete their differentiation, the majority of them undergoing atresia without ovulating. As the individual approaches pubescence, certain of the ovarian follicles increase greatly in size and rupture in order to free their ova. The periodic release of eggs from the ovary is termed ovulation.

After ovulation the collapsed wall of the follicle undergoes rapid structural changes. The cells of the granulosa and, in most species, the cells of the theca interna enlarge, become fat-laden and highly vascularized, thus forming a compact body called the corpus luteum. If impregnation ensues, the corpus grows and persists functionally until near the end of gestation. In the absence of fertilization it persists for a shorter period which varies according to the species. The primary function of the graafian follicle is the nourishment and discharge of the ovum, but it is also associated with an incretory function. The corpus luteum seems to be entirely incretory and its secretion is distinct from that of the graafian follicle.

I. OVULATION

Ovulation is a complicated process involving both hormonic and nervous mechanisms. Only within recent years has experimental evidence made possible a satisfactory explanation of this phenomenon. Morphological studies indicate that the graafian follicle enlarges appreciably during proestrus and early estrus. Extensive mitoses occur in the follicular walls and the secretion of liquor folliculi distends the antrum. The cumulus oöphorus loosens and frees the ovum and its surrounding corona radiata. The tissue between the graafian follicle and the surface of the ovary thins out somewhat and an avascular area, the stigma, appears on the surface of the follicle. As the pressure within the antrum increases, the whole avascular area is caused to bulge. The weakest point on the avascular area bulges still further, producing a nipple or cone which finally ruptures. Slight hemorrhage into the antrum may precede rupture of the follicle. Direct observations indicate that rupture of the follicle is a non-explosive process somewhat similar to the breaking of an abscess. A small jet of thin liquor folliculi first spurts from the burst follicle but the remainder of the fluid is more viscous and leaves the follicle more slowly. Ovulation in the mammal requires less than a minute, whereas in the frog the release of an egg from the ovary occupies a period of from four to ten minutes.

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In the past there have been many unsuccessful attempts to explain ovulation on the basis of local changes in the graafian follicle and the adjacent wall of the ovary. Most of the earlier views held that ovulation resulted from increased intra-follicular pressure, supposedly brought about in various ways, or from the enzymatic dissolution of the follicular wall. While both of these may be important auxiliary factors, they are for the most part incidental. The modern view is that ovulation is a differentiational phenomenon which is initiated by the gonadotropic hormones of the anterior lobe of the hypophysis cerebri. During the past few years the following pertinent points have been established:

1. The administration of purified FSH produces huge cystic follicles which do not ovulate. Thus ovulation cannot be explained on the basis of increased secretion of liquor folliculi and a consequent elevation of pressure within the antrum.

2. Hypophysectomy prevents pre-ovulatory swelling and rupture of the graafian follicle.

3. Ovulation can be induced in a variety of vertebrates by the administration of a proper mixture of FSH and LH. A correct ratio between FSH and LH seems to be absolutely essential for the full expression of the ovarian follicle. While ovulation in the rabbit is conditioned normally by cervical stimulation, it may be induced in normal or hypophysectomized subjects in the absence of sexual excitement by the administration of both FSH and LH. This seems to justify the assumption that ovulation is a growth phenomenon which occurs only in the presence of the proper anterior lobe principles.

4. Ovulation is not dependent upon the nerve supply to the ovaries. Normal ovulation may occur in ovarian grafts and in intact ovaries deprived of all nervous connections when the proper hypophyseal hormones are present.

5. The release of the ovulatory hormones from the anterior pituitary is almost certainly regulated by means of nervous pathways. Rabbits continue to copulate after surgical section of the infundibular stalk but ovulation does not occur in these animals. Under these conditions ovulations can be induced by the administration of FSH and LH. In normal estrous rabbits ovulation may be induced by electrical stimulation of a certain area in the pre-optic region of the brain, but this becomes impossible after section of the infundibular stalk. An increasing amount of evidence justifies the assumption that the secretion and/or release of ovulatory principles from the anterior hypophysis is controlled by nerve fibers which extend to it from the hypothalamic region of the brain stem.

The continued removal of eggs from the nests of certain birds may prolong the period of egg-laying very appreciably. In the light of what is known about ovulation in other vertebrates, one might suppose that this response is affected by means of a neural mechanism which prolongs the release of gonadotropins by the hypophysis rather than by a direct nervous stimulation of the ovaries. Endocrinologists are just beginning to appreciate the possibility that stimuli originating in the central nervous system may profoundly modify the functional states of endocrine glands.

II. THE OVARIAN HORMONES

A. The estrogenic hormone of the graafian follicle.—The first experiments leading to the identification of the ovarian hormones were attempts to prevent castration atrophy in the female by means of transplanting ovarian tissue. Near the turn of the present century, several investigators demonstrated that castrate atrophy of the uterus could be prevented by incorporated ovarian grafts. These first experiments demonstrated clearly that the atrophic changes following castration resulted from the withdrawal of an ovarian secretion rather than from nervous disturbances.

During the next few years there were attempts to develop desiccated preparations and ovarian concentrates which would be as effective as subcutaneous ovarian grafts in correcting the syndrome resulting from castration. At this period, the ovary was regarded as performing an incretory function but the ovarian secretion was conceived of as a single substance. While Adler's work was unconvincing, he claimed in 1912 that he was able to prepare aqueous extracts of ovarian tissue which had the property of restoring some degree of sexual activity in spayed females.

The next observations of importance were detailed histological studies of the ovary and the female accessories during the course of the normal cycle. It became possible to correlate ovarian changes with differences in the sex accessories and secondary sex characters. The estrous cycle of the guinea pig was described in minute detail in 1917 by Stockard and Papanicolaou (1). Similar studies were made on the rat by Long and Evans (2) and on the mouse by E. Allen (3). These observations were extremely significant since they suggested that the graafian follicle is the source of the estrogenic hormone, and since they indicated sensitive physiological indicators for the assay of estrogens. In these laboratory rodents, it was determined that a rhythmic sequence of changes occurred in the vagina and that these changes, followed by the vaginal smear technique, corresponded to rhythmic modifications of the ovary. Following oöphorectomy the vaginal rhythm ceases and the diestrous condition prevails.

The final physiological identification of an ovarian hormone awaited the epochal experiments of Allen and Doisy (4). These workers aspirated liquor folliculi from the vesicular follicles of fresh sow's ovaries and injected it into oöphorectomized mice and rats. Within fifty hours subsequent to the injection of fresh liquor folliculi, or alcoholic extracts of the fluid, to spayed animals the vaginal smear contained cornified epithelial cells typical of normal estrus. Histological examination of the sex accessories indicated that the vaginal wall had attained maximal growth, the superficial layers being cornified as during estrus. The uteri were hyperaemic and distended with fluid. Following withdrawal of the injections, the castrate condition supervened. When administered to immature rats and mice these extracts produced premature canalization of the vagina. The property of estrogenic substances to produce cornification of the vagina of the spayed rat or mouse was adopted as a simple and accurate method of bioassay.

Frank (5), using castrate mice as test animals, demonstrated that an estrogenic substance having the same properties as follicular fluid was present in menstrual and circulating blood of the human female. During pregnancy the amount in the blood was increased. In 1928 Zondek (6) reported that large amounts of estrogen were present in the urine of pregnancy. This was a timely discovery inasmuch as the urine from pregnant women and mares provided a cheap source of tremendous amounts of estrogen for chemical studies. This substantial background of animal experimentation culminated quickly in the chemical isolation and purification of the follicular hormone and chemically related estrogens.

During the 1920s many investigators believed that the ovary secreted only one hormone, i. e., estrogen. Here was a substance which fulfilled many of the functions ordinarily attributed to the ovary. Since it appeared likely that estrogen, when properly purified and physiologically tested, would substitute completely for the ovaries in castrate rodents, there seemed to be little incentive to look further for additional ovarian hormones. Other workers, however, remained skeptical and insisted that it was necessary to account for certain observations which had been made during the first decade of the present century.

B. The Hormone of the Corpus Luteum.—Long before any experimental evidence became available, there were many speculations regarding the function of the corpora lutea. Beard in 1897 suggested that the corpora lutea constituted an "organ of pregnancy" and speculated that this organ exerted an inhibitory influence upon ovulation and that it prolonged the cycle. Born (1900) was aware that the corpora lutea attained maximal differentiation during the period when blastocysts were ready to implant in the uterine mucosa and when the placental connections were being established. He indicated to his student, Ludwig Fraenkel, that he believed that the corpora lutea produced a substance which prepared the uterus for the reception and inplantation of the developing embryos. Born died before having opportunity to test experimentally his hypothesis and Fraenkel (7) proceeded to do so. Fraenkel bilaterally oöphorectomized rabbits immediately after mating, or removed the corpora lutea from mated individuals, and found that under these conditions implantation and pla-

centation did not ensue. He found that the removal of the corpora lutea previous to the twentieth day of pregnancy resulted either in absorption or abortion of the young.

Additional evidence that the corpora lutea are important in conditioning uterine reactions was provided by the classical experiments of Leo Loeb (8). He allowed estrous guinea pigs to mate with vasectomized males and, several days later, laparotomized the females and traumatized the uteri. He found that a tumor of decidual cells differentiated at the sites where the uteri were injured. This indicated that the corpora lutea produce the hormone which makes it possible for the endometrium to undergo decidual changes in response to the irritating effect of the blastocysts. Loeb (9) demonstrated also that extirpation of the corpora lutea hastened the next estrus and that removal of other parts of the ovary did not give this effect. Later it was found that ablation of the corpora during pregnancy might be followed by ovulations. On the basis of these early experiments, many believed that the corpora lutea secreted the ovarian hormone and that this was the only hormone concerned in the reproductive cycle.

Ancel and Bouin (10) extended Loeb's work to include the pseudo-pregnant rabbit. Since ovulation in this species occurs ten hours subsequent to copulation or cervical stimulation, luteinization can be induced in the absence of pregnancy by artificially stimulating the cervices or by mating with a vasectomized male. These two French investigators found that during pseudopregnancy the uterus underwent a type of proliferation which simulated that normally occurring during pregnancy. They found that this type of uterine growth, now designated as progestational proliferation, did not occur after the ablation of the corpora.

Herrmann (11) prepared lipoid extracts of corpora lutea and placental tissue and showed that they produced uterine growth and congestion.

In 1921, it was reported that corpora lutea could be shelled out of the ovaries of the non-pregnant cow by means of rectal palpation. This procedure was followed within two days by ovulation and estrus.

The chain of evidence establishing the incretory function of the corpus luteum was completed by Corner (12) and his collaborators. These workers prepared lipoid extracts of corpora lutea obtained from the ovaries of pregnant swine and found that such extracts produced progestational proliferation in the uteri of castrate adult rabbits, a reaction which cannot be elicited by estrogen alone. The recognition of this physiological endpoint in the rabbit was as instrumental in the isolation of the luteal hormone as was the vaginal response of the mouse and rat in the physiological identification of estrogen. These extracts, administered to rabbits which had been castrated eighteen hours after fertile matings, maintained pregnancy to term. They sensitized the uterus so that decidual reactions resulted from uterine trauma and, in short, produced all of the effects which earlier experiments indicated as attributable to the corpus luteum. The active extract of the corpus luteum was named "progestin". By 1933 several groups of investigators had announced the isolation of the hormone in crystalline form. Shortly thereafter, it became possible to synthesize the hormone of the corpus luteum, progesterone, from stigmasteral and from pregnanediol.

C. Androgenicity of the Mammalian Ovary.—There is substantial evidence indicating that the ovary may become capable of liberating appreciable amounts of androgen during unusual or abnormal circumstances. Steinach and Kun (13) reported that the luteinized ovaries of the guinea pig may exert masculinizing effects. Lipschütz (14) found that an ovarian graft persisting for three years in a castrate male guinea pig had restored fully the seminal vesicles and prostatic glands of the host. The experiments of Hill and collaborators (15, 16) indicate that ovarian homotransplants into the ears of castrate mice frequently become capable of maintaining secretion in both the seminal vesicles and prostate. A similar androgenic action of ovarian grafts persisting in the ears of rats has been reported by Deanesly (17). She did not find that the androgenicity of the ovarian grafts was conditioned by temperature as Hill maintains for mice.

Several workers have shown that crystalline progesterone produces masculinizing effects. It has not been proved,

however, that the chemical configuration of the progesterone molecule is not altered by the organism before androgenic effects are elicited. Nelson (18) found that progesterone resembled androgens inasmuch as it was capable of maintaining spermatogenesis in the gonads of hypophysectomized rats. Turner (19) described a spontaneous lesion of the rat's ovary which rendered it hyper-estrogenic and definitely androgenic. The absence of corpora lutea provided presumptive evidence that the masculinizing action of these ovaries was not due to progesterone.

The identity of the androgenic substances which derive from ovaries has not been ascertained. While the administration of large amounts of progesterone elicits masculinizing effects in certain laboratory rodents, the evidence seems to indicate that the ovaries may librate another androgenic compound which is similar to but not identical with that secreted by the testis. Deanesly found that gonadotropins causing extensive luteinization of the granulosa did not alter appreciably the androgenicity of the ovarian ear grafts in the rat. From studies upon the growth curves of male accessory glands, Hill and Strong concluded that the physiological response induced by ovarian grafts in the ears is not nearly duplicated by the experimental administration of testosterone propionate plus estrogens.

On the basis of studies undertaken in this laboratory, we believe that the androgenicity of the ovary is correlated with hypertrophy and hyperplasia of the theca interna of follicles which are forced experimentally to become atretic. In the case of ovaries persisting in the ears of castrate males, the hypophysis stimulates the differentiation of many vesicular follicles. These cannot ovulate because of an improper endocrine balance in the male and because of the complete encapsulation of the graft by dense tissue. When the cords of epithelioid cells derived from the theca interna persist and become abundant the ovary is made capable of secreting enough androgen to maintain secretion in the male sex accessories.

A permanent impairment of the rat's hypophysis and ovary results from the daily administration of 100 IU of estrogen during the first ten days of postnatal life. The follicles become atretic before reaching full maturity. The thecal cells become epithelioid and persist after other elements of the follicles have deteriorated. Some of the ovaries from adult animals of this type induce secretion in the seminal vesicles and prostate when such gonads are transplanted to the kidneys of long-time castrate male hosts. Since both kidney and ear grafts sometimes possess androgenic potencies, it appears that the temperature of the transplantation site is not the principal factor determining the androgenicity of the ovary.

In conclusion, an attempt has been made to present evidence upon which a modern theory of ovulation is based, and to outline the major events which led to the physiological identification of the ovarian hormones. Evidence has been presented which indicates that the ovary, under certain conditions at least, may secrete a male-sex-hormone-like compound which seems not to be progesterone.

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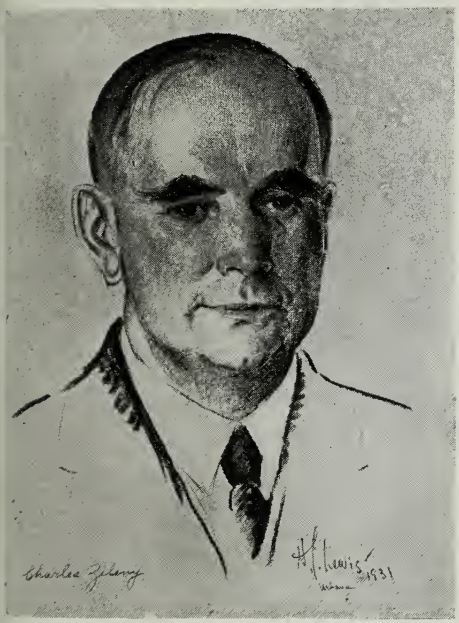
CHARLES ZELENY

1878-1939



CHARLES ZELENY died in December 1939 after an illness of four years. He was born of Czech parents at Hutchinson, Minnesota, and was one of five brothers, three of whom have had distinguished careers in science. He studied at the University of Minnesota and Columbia University, and took the doctorate in zoology at the University of Chicago in 1904. After five years at Indiana University he came to the University of Illinois in 1909 where he taught zoology and was active in research until his death. He was head of the department of zoology and chairman of the division of biological sciences from 1933 to 1937.

He was a professor in the strict sense of the word because to him, science was a faith and a way of life rather than a profession or an occupation. A keen student of experimental biology, he was extremely cautious and careful in analyzing data and drawing conclusions and had a passion for seeking out alternative explanations. He believed that the mechanistic viewpoint was the most productive approach to biological problems and that quantitative research would establish biology as an exact science comparable to the physical sciences. Perhaps his greatest delight was in simple, clear-cut experiments which gave definite answers to questions concerning the internal mechanisms of living things.

As a young man his principal research was an analysis of the factors involved in regeneration and he became known for his establishment of the principle of compensatory regulation in the organism. He maintained his interest in regeneration and the localization of developmental factors in the fertilized egg and spent many summers in later years experimenting with serpulids and other marine invertebrates at the Naples and Woods Hole biological stations. In 1914 he received a stock of the bar mutant of Drosophila which occupied his attention and that of many of his research students for twenty-five years. He learned that selection had its effect by sorting out and accumulating definite germinal differences. He made the first measurements of the rates of mutation within a single series of multiple allelomorphs and, with his research students, analyzed in detail the effect of temperature and other environmental factors on the somatic manifestation of this bar series of multiple allelomorphs.

Mild-mannered and kindly, he had an unusually wide circle of friends. He was greatly interested in international affairs and was saddened by the approach of the present war. He was an ardent and skilled outdoorsman and made many trips into the north woods with his family or a crony or two.

David H. Thompson.

EUGENE RICHARD DOUGHERTY

1902-1940

ON NOVEMBER 4th, 1940, the Academy lost an esteemed member. Though his affiliation with our society was of relatively short duration his wholehearted efforts as Vice-President and Chairman of the Local Committee, at the time of the Springfield meeting, as well as his contribution to the scientific papers in the section of Zoology, entitle him to special recognition at this time.

Mr. Dougherty was born in Beaver Falls, Pennsylvania, June 22, 1902. After graduating from Beaver Falls High School he attended Geneva College, in Beaver Falls. He was graduated from St. Louis University in 1928 with a bachelor's degree. Graduate studies were pursued at St. Louis University and the University of Buffalo.

In 1934 Mr. Dougherty became associated with Springfield Junior College. Springfield, Illinois, in the capacity of instructor in Biology. In 1939 he was promoted to the position of Dean.

It was in connection with the Springfield Meeting (1938) of the Academy that Mr. Dougherty first took an active part in the organization. His generous services in making arrangements for that meeting are gratefully remembered by officers and members alike.

Mr. Dougherty's untimely death occurred suddenly following a brief illness. He is survived by his wife, Flora Pullinger Dougherty.

GILBERT WRIGHT.

A TRIBUTE IN MEMORY OF ROSE M. CASSIDY

In the passing of Miss Rose M. Cassidy on January 8, 1941, the Illinois State Academy of Science has lost one of its most loyal members.

Miss Cassidy was a graduate of the University of Michigan, and later took advanced work at the Universities of Chicago, Utah, Wisconsin and Notre Dame. For the past twenty-three years she has been a member of the Science Department of the Maine Township High School.

Miss Cassidy became a member of the Illinois State Academy of Science organization in 1930, in the same year that the Maine Chemistry Club, which had recently been organized under her sponsorship, became affiliated with the Junior Academy of Science. In the very early phase of the existence of the Junior Academy, she was among the first to recognize its possibilities and was ready to assume responsibilities and to give a vast amount of time and energy to constructive work in its development.

Through the Maine Chemistry Club Miss Cassidy was able to demonstrate the foundation principles and ideals upon which the Junior Academy movement was based. In this club under her faithful guidance were fostered scientific imagination, originality, and invention, together with accuracy in learning and skill in technical procedures. Here, also, the pleasure of scientific creative activity was enhanced by the healthy competition with other clubs in the annual exhibit of the Junior Academy. The success of Miss Cassidy as a sponsor and leader is shown in the record that the club received highest honors in the Chemistry Division of the annual exhibits for seven of the past ten years.

Miss Cassidy was made chairman of the Chemistry section in the Junior Academy for 1932-1933 and again in 1933-1934. She was then appointed to serve as co-chairman of the Annual Competition 1934-1935 and in the following year, 1935-1936, she served as co-chairman of the Junior Academy. In 1936 she was chosen the Illinois editor for Science Aid Service, the official organ of the cooperating Junior Academies of Science, in which capacity she served with distinction during the past four years.

At the annual meetings of the Junior Academy she displayed unusual talent as an executive. Her plans were well formulated and the staff of helpers well chosen while she in person directed the work, giving the timely word or active help wherever it was needed.

Miss Cassidy never ceased to be a student. She read widely in fields of science, world affairs, poetry and art,— sources from which she derived inspiration for daily work. She transmitted to her pupils appreciation of the beauties of nature which she had learned from her father, a great nature-lover, with whom in her earlier years there was a great companionship. From her mother, gifted in music, she learned beauty in rhythm and in exquisite techniques.

Although gifted in many lines, Miss Cassidy found her greatest joy in work with young people, where she watched youthful minds develop methods of scientific thinking with a measure of creative genius appearing under the guidance of this gifted sponsor. In her home, open evenings to club members, programs were planned and projects organized by committees from the Maine Chemistry Club.

With a humility of spirit often found in the truly great she devoted time and energy to the development of cultural ideals in the lives of her pupils. Honesty and integrity were incorporated into her teaching along with methods for transmuting scientific dreams into forms of reality. She had assumed responsibilities from her early youth and worked with all her great fund of energy to put order into the lives of those about her. She loved the world and she loved people and was never without deep interests in science and in humanity. These interests which might have been only a pleasant pastime to be put aside and forgotten as the years passed, grew with her and enriched her life.

Miss Cassidy belonged to several scien-

tific organizations. For many years she was a member of the Illinois Association of Chemistry Teachers. While in the West she was a member of the Sierra Club. The beauty of the Western canyons inspired her to a study of the plant life of those regions and for a number of years she helped to organize this material and to make collections for the Smithsonian Institute.

At one time in her college dramatics, she was asked to select a drama suitable for presentation by the club. She unearthed an Elizabethan treasure full of rich humor and appealing traits of character. Her interest led her to continue this search until she had the nucleus of a volume which was shared and published by an English teacher. This study was a contributing factor in her love and admiration for the British people.

In the memorial address for Miss Cassidy, Rev. Dr. Walter D. Spangler quoted from several of her favorite poems. A quotation from a poem by Henry Wadsworth Longfellow aptly describes the life of Miss Cassidy as her friends and coworkers in the Junior Academy have known her.

"Among the many lives that I have known,
None I remember more serene and sweet,
More rounded in itself and more complete,
Than hers, who lies beneath this funeral stone.
These pines that murmur in low monotone,
These walks frequented by scholastic feet,
Were all her world; but in this calm retreat
For her the teacher's chair became a throne.
With fond affection memory loves to dwell
On the old days, when her example made
A pastime of the toil of tongue and pen;
And now amid the groves she loved so well
That naught could lure her from their grateful shade,
She sleeps, but wakes elsewhere, for God hath said, Amen."

Always she used her mind, was a cheerful companion, high spirited and fearless, reaching out for what was fine and beautiful, and scorning what was base.

The sympathy of members of The State Academy of Science is extended to the bereaved family.

To Miss Minnie C. Cassidy I am grateful for collaboration in the preparation of this paper.

Rosalie M. Parr.

STATE OF ILLINOIS
DWIGHT H. GREEN, Governor

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ANNOUNCEMENTS

Attention is directed to the fact that the Committee on Research Grants of the Illinois State Academy of Science has at its disposal a small sum of money to be disbursed in support of worthy research projects. Applications for grants will be accepted up to and including March 31, 1942. It is customary to give preference to scientists connected with the smaller institutions of the state.

Requests for grants should be accompanied by a brief statement of the training and experience of the applicant, the purpose of the investigation, and the estimated cost. Previous publications should be listed. At least two letters of recommendation should be transmitted directly by their authors. Correspondence may be addressed to William C. Rose, Chairman, Department of Chemistry, University of Illinois, Urbana, Illinois.

1942 MEETING

URBANA—MAY 8-9

GENERAL CHAIRMAN: George E. Ekblaw, 216 Natural Resources Building, Urbana, Illinois

SECTION CHAIRMEN 1941-42

Agriculture: C. H. Oathout, Macomb, Ill.

Anthropology: Donald E. Wray, 604 Caroline St., Peoria, Ill.

Botany: Paul D. Voth, University of Chicago, Chicago, Ill.

Chemistry: N. D. Cheronis, 5556 Ardmore Ave., Chicago, Ill.

Geography: Joseph Van Riper, Southern Illinois State Normal University, Carbondale, Ill.

Geology: A. H. Sutton, University of Illinois, Urbana, Ill.

Physics: F. L. Verwiebe, Eastern Illinois State Teachers College, Charleston, Ill.

Psychology and Education: J. M. Hughes, Northwestern University, Evanston, Ill.

Social Science: C. W. Schroeder, Bradley Polytechnic Institute, Peoria, Ill.

Zoology: Orlando Park, Northwestern University, Evanston, Ill.

Papers in Agriculture

Extract From the Report of the Section Chairman

Eight papers were presented at the Evanston meeting, six of which are herewith published. The others were:

Burlison, W. L. and Fuelleman, R. F. *University of Illinois, Urbana,*—Pasture Studies of Brome Grass, *Bromons inermis* Leyss.
(Being published in enlarged form in the *Journal of American Society of Agronomy,* Vol. 33, No. 10, October, 1941.)

Douglass, T. J., *Illinois State Normal University, Normal,*—Mulching of Strawberries.

Nine people attended the meeting and re-elected Mr. Oathout chairman for 1941-42.

(Signed) C. H. Oathout, *Chairman*
Macomb, Illinois

RELATION BETWEEN MOISTURE CONTENT OF THE SOIL AND THE OPTIMUM DEPTH OF PLANTING CORN

GEORGE H. DUNGAN
University of Illinois, Urbana, Illinois
and
WILBUR C. BROKAW
Bradford High School, Bradford, Illinois

In 1934 the corn seedlings in one particular series of hand-planted plots of the Illinois Corn Performance Tests[1] were markedly more vigorous and uniform than those in the other series.

The question naturally arose as to the cause of this difference. Since all the series were planted with the same kind of corn, the difference could not have been due to a difference in quality of seed The cause of the variation had to be due to some difference in the manner of planting. Since the soil to a depth of three inches was unusually dry there was the possibility that depth of planting was the factor.

Growth of Corn Seedlings in Dry Soil.—In order to determine the influence that moisture content of the soil has on the growth of corn seedlings, six samples of soil were prepared from a field being summer fallowed on the Agronomy South Farm at Urbana. Some soil was dried on a bench in the greenhouse. It was mixed with moist soil in such proportions as to make samples of two different moisture contents. One contained 3.3 and the other 4.6 percent moisture. Four other samples were taken from different levels in the field so as to get soil carrying diverse amounts of moisture. The moisture content of the various samples thus collected was as follows: 5.2, 5.5, 6.8, and 8.1 percent.

One hundred kernels of corn were planted in each lot of soil in the greenhouse. At the end of seven days the seedlings were dug up and shoot and root measurements were made. The results are shown graphically in Figure 1.

No growth occurred in the soil containing 3.3 percent of moisture. Growth was apparently normal in the soil containing 8.1 percent of moisture. Seedling growth in the other lots of soil was roughly in proportion to the amount of moisture present. The development of roots in soils lacking in moisture was strikingly greater than the development of plumules in the same soils. This shows that the minimum amount of moisture for plumule growth is at a higher level than it is for root growth. It also indicates that relative dryness of soil is a factor in the germination and seedling development of corn.

Depth of Planting Corn in Dry and Moist Soils.—In order to determine what influence depth of planting has on the growth of corn plants and the yield of grain a field experiment was conducted in 1939 and in 1940. Seed of good quality was planted by hand at depths ranging by one-inch intervals from one to six inches. To attain the desired depth of planting the soil in each hill was opened with a spade to approximately the depth wanted. Three kernels of corn were dropped into the opening, and with the end of a ruler resting on top of the kernels, the soil was filled in to exactly the

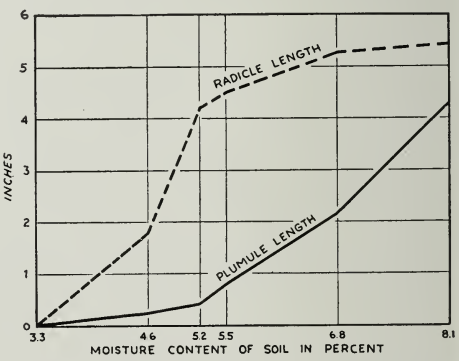

Fig 1.—Average length of plumules and radicles produced by corn seedlings during seven days' growth in soil containing different percentages of moisture.

[1] Dungan, G. H., Holbert, J. R., Mumm, W. J., Bigger, J. H., and Lang, A. L. Illinois corn performance tests—results for 1934. Ill. Agr. Exp. Sta. Bull. 411:58, 59. 1939.

TABLE 1.—INFLUENCE OF DEPTH OF PLANTING CORN IN A DRY SOIL AND IN A MOIST SOIL ON PERCENTAGE FIELD STAND, HEIGHT OF PLANTS, AND YIELD OF GRAIN PER ACRE. URBANA, ILLINOIS.

Depth of planting	Proportion of a perfect stand	Average height of plants 36 days after planting	Yield of shelled corn per acre
inches	*percent*	*inches*	*bushels*
Dry Soil—1939			
1	83	23.8	78.0
2	98	29.3	110.5
3	95	32.1	113.2
4	92	29.6	111.3
5	88	28.8	100.6
6	70	24.4	78.4
Moist Soil—1940			
1	95	28.0	105.3
2	83	27.5	94.7
3	88	26.2	103.0
4	64	25.5	72.8
5	67	24.1	81.1
6	67	23.0	73.2

one-inch level, two-inch level, etc. Each hill was considered as a separate plot or unit. Twenty-two separate hills were planted at each depth.

The amount of rainfall prior to and immediately following planting was very different in the two years. Soil conditions at planting time in 1939 were dry, but in 1940 they were moist and favorable. In 1939, a total of .92 inch of rain fell during the three weeks just ahead of corn planting and only .03 inch fell during the ten days after planting. This difference in the moisture conditions at planting time and following planting is reflected in the germination, plant height, and yield records which are shown in Table 1.

In the dry soil the highest percentage field stand was obtained from the two-inch planting depth. In the moist soil the best stand was from the one-inch depth. In the dry soil the greatest average plant height 36 days after planting came from the three-inch planting. One-inch planting produced the tallest plants in the moist soil, whereas the one-inch planting in the dry soil produced the shortest plants.

The yields also show wide differences attributable to depth of planting in dry and moist soil. The lowest yield in 1939 was from one-inch planting whereas in 1940 the highest yield was from the one-inch depth. Good yields in dry soil were obtained from the two-, three-, and four-inch planting depths. In the moist soil the yields dropped off sharply for plantings deeper than three inches.

Apparently the optimum depth of planting corn depends upon soil conditions. If the soil is amply supplied with moisture, corn can be planted as shallow as one inch with the expectation of maximum yields. If, on the other hand, the surface soil is dry, corn should be planted deeper than one inch to get maximum yields. The exhaustion of the seedling as a consequence of deep planting is seemingly less harmful than the stunting influence of insufficient moisture near the surface.

PRELIMINARY REPORT ON CORN AND PASTURE FERTILIZATION IN SOUTHERN ILLINOIS

Robert C. Cassell

Southern Illinois Normal University, Carbondale, Illinois

Corn Fertilization

In 1940 an opportunity was afforded at the College Farm to study the effects of complete commercial fertilization of corn by the hill drop method. In the following described corn experiments as well as the pasture experiment it should be borne in mind that the data takes into account only the one year's results. Practical implications must necessarily await confirmation in subsequent experiments.

The first experiment was on a three acre plot of ground where a three year stand of alfalfa had just been plowed. The field was on rolling upland of Ava Silt Loam which, before the experiment was started, tested slightly acid, between 6.5 and 7.0 pH. The test for phosphorus showed only a moderate amount present, but enough to grow alfalfa. The soil, however, proved to be low in potassium.

The field was planted two kernels to the hill with Funk's G-Hybrid 135. The fertilizers were applied at a rate of 200 pounds per acre. The yields from the fertilized plots were calculated from two replications of four 96 hill rows. The unfertilized yield was obtained from 42 rows rather than eight as unfertilized checks were left at regular intervals across the field. The only adjustments made in yield were for moisture percentage of the corn at harvest time and for missing hills.

From the data presented in Table 1, it would be difficult to select any one fertilizer mixture for recommendation. Practically any fertilizer except the straight superphosphate (0-20-0) produced a sufficient increase in yield to justify its use and any fertilizer listed in the table above the 4-16-4 would be well justified under the conditons of this experiment. It would seem that any mixture with a little nitrogen, a medium quantity of phosphate and a high percentage of potash would be adequate. The two high yield producing fertilizers (2-12-6 and 0-8-24) gave yield increases over the unfertilized corn of 19.38 and 16.94 bushels per acre respectively. It may also be worthy to note that the plots with the four fertilizers containing nitrogen in the mixture averaged 8.29% missing hills, the unfertilized corn 10.21% and the six fertilizers with no nitrogen 12.48%.

Table 1.—Fertilizers Hill Dropped at a Rate of 200 Pounds Per Acre, 1940.

Fertilizer	Acre yield *bushels*	Moisture in grain at harvest *percent*	Approximate cost of fertilizer per acre
2–12–6..	81.62	17.4	$3.14
0–8–24..	79.18	18.5	3.96
0–10–20.	75.14	21.0	3.70
3–12–12.	74.53	20.6	3.85
3–18–9..	74.33	14.8	4.22
0–12–12.	72.05	18.0	3.26
0–20–20.	70.08	18.7	5.06
4–16–4..	68.64	14.1	3.84
0–20–10.	68.36	16.9	4.00
Unfertilized...	62.24	18.4	0
0–20–0..	61.58	20.1	2.66

In another 10 acre fertilizer experiment, 13 Funk hybrids and two replications of open pollinated corn were fertilized at a rate of 65 pounds per acre in comparison with check plots of each not fertilized. Six other Funk hybrids and two replications of the same open pollinated corn were fertilized at a rate of 120 pounds per acre in comparison with check plots of each not fertilized. The corn was all check planted, two kernels to the hill, and hill fertilized

The author wishes to acknowledge the assistance of Mr. Irvin Peithman, Superintendent of the College Farm, and Mr. Leo Sharp, student employee, in carrying on the routine work of the fertilizer trials. Funk Bros. Seed Co., and the Armour Fertilizer Works furnished the hybrid seed corn and fertilizer respectively.

Table 2.—3-12-12 Commercial Fertilizer Hill Dropped at Rates of 65 and 120 Pounds Per Acre, 1940.

Corn	Treatment	Average acre yield *bushels*	Average increase per acre *bushels*
13 hybrids	Unfertilized	59.25	.....
Same 13 hybrids	Fertilized (65 lbs. per A)	65.96	6.71
Open Pollinated	Unfertilized	43.49	.....
Same Open Pollinated	Fertilized (65 lbs. per A)	44.31	0.82
6 hybrids	Unfertilized	57.20	.....
Same 6 hybrids	Fertilized (120 lbs. per A)	69.71	12.51
Open Pollinated	Unfertilized	42.67	.....
Same Open Pollinated	Fertilized (120 lbs. per A)	51.95	9.28

with a 3-12-12 commercial fertilizer. Adjustments in yield were made for moisture percentage and missing hills.

Where the 3-12-12 fertilizer was applied at a rate of 65 pounds per acre an average increase of 6.71 bushels per acre was obtained over the yield of the same hybrids not fertilized. When the rate of application was almost doubled (120 lbs. per acre), the average increase in yield was almost doubled (12.51 bushels per acre). In the case of the open pollinated corn 65 pounds of fertilizer per acre increased the yield only 0.82 bushels per acre, but an application of 120 pounds per acre increased the yield 9.28 bushels per acre. The greatest single hybrid increase due to fertilization at the rate of 65 pounds per acre was 17.94 bushels per acre and in only one case among the 13 hybrids did the unfertilized plot outyield the fertilized plot and that was by 7.32 bushels per acre. The greatest single hybrid increase due to fertilization at the rate of 120 pounds per acre was 17.25 bushels per acre and the least single increase was 6.19 bushels per acre.

Pasture Fertilization

At the college farm there is an old blue grass pasture. The pasture has been over grazed and the stand of blue grass is poor. The only improvement the pasture has received is an application of limestone made a few years ago. The soil at present tests sweet, but there is a deficiency of both phosphorus and potassium. In 1940, one-fourth acre plots were laid out and given treatments as shown in Table 3. The nitrogen fertilizer was made up of approximately equal portions of 16% nitrate of soda and 20% sulfate of ammonia. The fertilizers were applied by means of the fertilizer attachment of a disc grain drill.

The 1940 season was unusually dry and only four cuttings were obtained; the last one August 14. There were no fall rains to produce a late pasture; this and the fact that the pasture was thin to begin with accounts for the small amount of green material produced even on the fertilized plots. In all of the treatments the greatest in-

Table 3.—Pasture Fertilization, 1940.

Treatment	Date of treatment	Yield of green material per acre (season) *pounds*	Increase per acre *pounds*	Cost of fertilizer per acre
1. Check	.....	1,573	.....	.....
2. 4–12–4 (250 lbs. per A)	April 1	4,840	3,267	$ 4.31
3. Nitrogen (300 lbs. per A)	May 7	4,114	2,541	5.80
4. (2 and 3)	(2 and 3)	5,292	3,719	10.11

crease in yields over the check was obtained with the first and second cuttings. From the data presented in Table 3, it is to be noted that the 4-12-4 fertilizer produced the most efficient increase of green material. Where only 1,573 pounds of green material were obtained from the untreated plot, 4,840 pounds (over three times as much) were obtained from the application of 250 pounds per acre of the 4-12-4 fertilizer at a cost of $4.31 for the fertilizer.

ADAPTING THE TEACHING OF AGRICULTURE TO THE NEEDS OF THE COMMUNITY

Burdette Graham

Prairie City, Illinois

ABSTRACT

One of the primary needs of the community is to secure and apply information as soon as possible after it is known. I feel that in too many cases the gap between the time a thing is proven to be good and the time when it is put into practice is too great. All of the agencies which are experimenting and carrying on research for new and better practices are doing a fine job. They are also doing a fine job in placing the information they have in the hands of schools and extension agencies in the local communities. A way must be found, however, to shorten the gap between the time a thing is known and the time it is applied. I am reminded of the boy who in school was taught many phases of soil conservation. When he returned home to the farm after having been away for several years he found that the gully he had learned how to control when he was in school, had taken the school house and much of the surrounding land with it. While he was studying about soil conservation control the gully went right on taking its toll. He thought what he was learning was for some one else to apply. When he realized it was for him to apply much damage had been done which could never be repaired. The gap was too great between the time a thing was learned and the time it was applied. In this article four suggestions are made to help overcome this gap.

Find the Need by Community Surveys.—The first suggestion is to find the real needs of the community. This can best be done by means of surveys of the various areas of activity. Surveys of various kinds can be used, such as: questionnaires, conferences, tours, and personal observation. From these surveys one with training should be able to arrive at the needs with accuracy.

Create Interest in Doing Something About the Needs.—One of the best means of creating enough interest to secure action in working toward the goal of meeting a need is to direct the attention of adults, school boys, and the youth toward the goal. Showing the results of the surveys of the community to all groups, and getting them all to work toward a certain goal is the first step. They may be made fully conscious of the needs by tours, discussion, pictures, and many other means. Once the people of a community see a need they will do something about it if they know what to do. Some means must be used which is effective, interesting and accurate to show them what and how to do.

Community Demonstrations Get Action.—Community demonstration is the third suggestion which I have to make to help get ideas into action and takes many forms. The boy's supervised practice programs are good examples. They do not touch enough of the problems of the farm however, so something more is needed. The community demonstration is a practice set up in the community so that people can see it often, and under home conditions. It is local so that it is talked about many times, and so its good and bad points brought up and discussed by all. If the demonstration is good, and it should be, people are in favor of the practice demonstrated, and that is just what we hope they will be.

As an illustration of the effectiveness of a community demonstration, let us consider one which we used effectively in

this community. It was one showing contour farming of corn, a practice which, in everyone's mind, was one which could never be used and would not be effective, would be a nuisance, would be laughed at. We established a small demonstration field on two sides of the community, along the road where people could see them. We visited them on tours and discussed them at meetings. The following year the same farmers increased their own contour acreage by 30 percent and several other farmers for the first time tried a field on the contour, proof enough of the effectiveness of the demonstration in getting action.

Other demonstrations which are being used are: terraces, windbreak planting, grove planting of hedge trees, forest plantings, sod flumes, diversion ditches, swine sanitation, grass waterways, and terrace outlets.

Show the Demonstration to People.—Good demonstrations should be visited by many people, and at times when they are interested, and when there is something of interest to see. Visit terraces during a big rain, or visit a swine sanitation demonstration when the pigs are showing the results of clean raising. Tours are always good, as people see things and discuss them better when in a group. What one does not see another will. A picture record of the construction and results of the practice will be good to show to future groups. Once people see a thing they are much more in a mood to attempt it, if it is something they can use profitably.

By following the steps outlined above, a program in agricultural education can be made to result in action, which is the desired end of such education. The four steps outlined above followed out with any practice will do much to shorten the gap between the time it is known and the time it is applied on the farms. Overcoming this lag is the greatest need our communities have. We must adapt our teaching to meet this need, or our communities will find some other way to accomplish it.

PALATABILITY OF PASTURE PLANTS

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Palatability is a relative term. When applied to vegetation with respect to animals, the cataloging of palatability of plant species is extremely difficult. If it were possible to isolate certain variables and subject each factor to analysis with relation to palatibility, the problem would be greatly simplified.

Methods of analysis are contingent upon animals, vegetation, environment and climate. During no period in the grazing season, whether it be a month, a week, or day, do any of the above factors function in the same manner. The most static, if they can be termed as such with respect to palatability, are the animals. Vegetation changes from day to day at a surprising rate of speed, animals more slowly. A large group of animals on a given area tend to balance among themselves small changes due to environment. The converse is true with vegetation. Different species have dissimilar requirements of moisture, light, and temperature; their maturity differs. An ideal environment for one species may not be best for another. Pasturing a single species of forage as Kentucky bluegrass (*Poa pratensis*) would obviously provide a measure of palatability as related to maturity of this plant, but would not be a criterion of the palatability of this grass as compared to some other species. Animals with no alternative or choice must necessarily derive their nourishment from what is at hand, whereas a mixture or series of mixtures would provide a choice which would be conditioned by species, maturity, and a number of factors so closely linked as to be inseparable.

This paper presents briefly some results of palatability studies inaugurated in 1938.

Methods of Approach.—In attempting to place palatability value on a plant species, the best approach is through the use of grazing animals and parallel botanical analyses of vegetation. Yield data will also indicate the relationship between palatability and available vegetation; however, the values assigned to a

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particular species or mixture of species do not distinguish definitely between qualitative and quantitative results.

In attempting to assess the palatability value of pasture plants, they should all be offered to the animals at a stage of growth where the majority of species are at a stage of maturity most acceptable to the animal. Undoubtedly, this stage is during the early part of the grazing season. It is difficult, if not impossible, to project an experiment in which all species would be pastured at the same stage of maturity. If this were possible the variable of animal changes is introduced.

A second factor indicates that the animals should be of similar age and breed. Obviously, different aged animals may well have different tastes with respect to vegetation. For example, aged animals (sheep) may have greater requirements for body maintenance, particularly during gestation periods, and therefore might easily be less selective than an immature animal. Certain breeds of sheep are larger or smaller than others and introduce a variable into the picture difficult to analyze. Acclimatization has not been mentioned. However, a band of sheep just arrived from a western range and placed on a palatability test would probably be less selective than the same band following an acclimatization period.

Botanical analyses are considered as an essential adjunct in palatability studies. The method of analysis is of course arbitrary; but when a large number of species plots are used, the matter of time becomes most important. Hence, that method affording the most rapid analysis is used. The results obtained are qualitative, but the application is remotely quantitative.

Grazing animals, particularly sheep, are selective and it can be assumed that they will consume the more palatable species whether it be weed, grass, or clover. This is unquestionably one of the fundamental bases for assessing palatability values to plant species.

That sheep are fairly constant in their grazing habits can be seen by close observation. When forage is plentiful—no long period of time is necessary to satisfy their appetites—the daily grazing periods are short. Usually this does not exceed an hour's time. If the experimental plots are large, they need not graze all plots before obtaining their fill. Under the above conditions, periods of grazing seem to follow a time schedule; i.e., beginning at 4 a. m. to 5 a. m.; 7 a. m. to 8 a. m.; 10 a. m. to 11 a. m.; 1 p. m. to 2 p. m.; etc., until dusk. Certain external conditions may change the direction of grazing—a strong wind tends to cause them to rest on the lee side of the field or plot, and when grazing, to travel into the wind. When available forage is short (literally), a much longer period of time is required for the animals to obtain sufficient to satisfy their needs.

Methods of Determining Palatability.—Seventy-two plots in duplicate, each 1x2 rods in area, were seeded in the fall of 1936 and the spring of 1937 with pure seedings and mixtures. Some 20 species were seeded in various combinations and in most cases alone. The position of an individual plot in the series was predetermined, and a comparison between certain species and mixture plots was expedited by using a single species on one plot and mixtures of this species in combination with other species on adjacent plots. An example of this was a mixture containing red clover, Kentucky bluegrass and redtop on one plot, and three adjacent plots containing the same grasses, but with alfalfa, alsike clover and white clover as the legumes.

If the entire series of plots were used in this paper the mass of data would be unwieldy and confusing; therefore, the writers have deemed it best to use a group of six plots to illustrate the procedure and results.

Botanical analyses by means of a point quadrat were made in the fall of 1937 and in the summers of 1938, 1939, and 1940. Results were expressed in terms of percentages for purposes of comparison. The point quadrat method in practice does not provide a measure of actual weight of the component vegetation on a plot, but does indicate the relative incidence of a particular species. The relationship between point quadrat analyses, occurrence, and actual quantity of any species in a plot becomes more directly comparable as the season advances and as the vegetation is consumed by animals.

Yields of dry matter were obtained in the spring of 1938 and again in the fall from each plot for purposes of comparison.

In May of 1938, seventy even-aged sheep were turned on the plots. From a platform or tower located in the center of the series of plots, observations were made of the number of sheep on each plot at intervals of 15 to 30 minutes over a period of three days and the data recorded. These observations coupled with the botanical analyses, forage weights, and observations form the basis for the determination of palatability as recorded in the results.

TABLE 1.—RELATIVE PERCENTAGES OF SPECIES IN PLOTS ON SEPTEMBER 29, 1937, MAY 3, 1938, AND JUNE 13, 1940.

Species	Plots																	
	1			2			3			4			5			6		
	9/37	5/38	6/40	9/37	5/38	6/40	9/37	5/38	6/40	9/37	5/38	6/40	9/37	5/38	6/40	9/37	5/38	6/40
Ladino clover	86	68	14															
Bromegrass				21	13	36	1							6			5	
Orchard grass							1						2					
Tall oat grass				6									4	5				
Timothy	4	16		52	76					29	47	54		4			6	
Redtop			3			4			2	9	4	4	1		5	87	83	67
Kentucky bluegrass	1	11	43		6	9	3	2	35	2		10	89	77	87	7	6	18
Alfalfa										40	49	14						
Reed canary grass							86	98	47					6				
White clover			6						2									
Weeds	9	5	34	21	5	51	9		14	20		18	4	2	8	6		15

Results and Discussion.—The six plots included in this discussion were seeded with the following species: 1. Ladino clover; 2. Timothy; 3. Reed canary grass; 4. Alfalfa, timothy, redtop; 5. Kentucky bluegrass; 6. Redtop.

Preliminary point quadrat readings were made on September 29, 1937. The results, as well as readings made on May 3, 1938 and June 13, 1940, are shown in table 1. Percentages are not an expression of dry weight, but indicate the relative percentage of each species.

The absence of grazing animals on the plots in 1937 and a single clipping of the plots in June allowed the taller growing species to recover by September 29, and in some cases suppressed the incidence of white clover, *Trifolium repens.*

Another factor which may result in the presence or absence of white clover is that of root interaction with the subsequent elimination or entrance of certain species from plots.

Table 1 illustrates the changes in botanical composition over the period of four years. A measure of relative palatability is found in the percentage of a species remaining on the last analysis date, June 13, 1940. In Plot 1, Ladino clover decreased from 86 percent in 1937 to 14 percent in 1940. On the same plot Kentucky bluegrass constituted 41 percent of the cover in the latter year. These percentages at once illustrate the high palatability of the clover and the aggressiveness of the bluegrass. Plot 2 contained 76 percent timothy in 1938 and none in 1940. Plot 3 was seeded to reed canary grass. This grass has been considered unpalatable. The figures in the table bear out this statement, for in 1940 47 percent of the vegetation was reed canary grass and Kentucky bluegrass occupied 35 percent of the remaining space. Similar relationships are illustrated in Plots 4, 5, and 6.

Tables 2 and 4 are particularly interesting in that they provide a direct measure of comparative palatability. Yields of dry matter were obtained on May 3, 1938, previous to turning in sheep, and again on June 9 at the end of the grazing period. Similar data are shown for the period May 15 to June 29, 1939. The amount of forage remaining or residual yield, expressed in percentages, indicates the relative palatability of the various species and mixtures. The factor of growth occurring during the grazing period is applicable to all species; i.e., the grand period of growth for all of the species considered is encompassed by the dates May 3-June 29. It is also a period when these plants are most succulent and therefore if a difference in palatability occurs it is borne out in the differences in consumed forage.

Table 2.—Yields of Dry Matter in Pounds Per Acre. May 3 and June 9, 1938.

Plot	Seedings	Yield pounds per acre May 3	Yield pounds per acre June 9	Forage remaining %
1...	Ladino clover...	2,424	684	28.0
2...	Timothy...	1,332	324	24.3
3...	Reed canary grass.	5,280	2,832	56.4
4...	Alfalfa, Timothy, Redtop..	2,136	372	17.4
5...	Kentucky bluegrass	852	1,020	119.7
6...	Redtop....	1,548	1,200	77.5

Table 3.—Total Number of Sheep Recorded as Grazing on Each Plot Over a Period of Four Days, May 4 to May 7, 1938, A Total of 70 Sheep was on the Plots, and the Observations Made at Regular Intervals were 70.

Plot	Number of sheep on plots
1	44
2	26
3	0
4	30
5	5
6	5

Plot 5 gave a larger yield at the end of the period than on the first sampling date. Kentucky bluegrass, *Poa pratensis*, was the dominant species. Redtop, *Agrostis alba*, and reed canary grass, *Phalaris arundinacea*, can be placed in a second group of palatability. Alfalfa, *Medicago sativa*, Ladino clover, *trifolium repens Latum*, and timothy, *Phleum pratense*, can all be placed in a group as species of relatively high palatability. Some species of the latter groups are

Table 4.—Yield Data for 1939. Plots Grazed in Interim by Sheep

Plot	Yield pounds per acre May 15, 1939	Yield pounds per acre June 29, 1939	Forage remaining %
1.....	564	Trace	0.0
2.....	756	372	49.2
3.....	864	916	106.0
4.....	1,836	240	13.0
5.....	432	360	83.3
6.....	480	132	27.5

distinguished as being more palatable than others.

Sheep Data.—The number of sheep grazing a plot at a single specified time is not an indication of palatability of the species, but when a number of observations are made and the number of animals totaled it is safe to assume that the figure obtained is an indication of palatability. Certain factors other than palatability may prevent the animals from grazing some plots and must be considered. The location of a plot is an example. If located near a farm road, the traffic may cause sheep to avoid it. Table 3 shows the total number of sheep on each plot—the total of 70 observations.

Palatability of Kentucky Bluegrass and Redtop.—In 1939 two plots—one seeded to Kentucky bluegrass, *Poa pratensis*, the other to redtop, *Agrostis alba*—were used to test the palatability of these species. The palatability of both species is considered as low during their mature stage of growth. An enclosure was placed on the plots, encompassing one-half of each species. Two sheep were placed within the enclosure for a period of eight days. Yields were obtained at the beginning and at the end of the period. The results are shown in table 5. It is interesting to note that the apparent palatability of Kentucky bluegrass, as indicated by the percent of forage remaining, was much higher than that of redtop. The effect of maturity on palatability is illustrated in this table.

TABLE 5.—COMPARISON OF REDTOP *(Agrostis alba)* AND KENTUCKY BLUEGRASS *(Poa pratensis)* IN MATURE STAGES OF GROWTH. PERIOD JULY 1 TO JULY 8, 1939.

Plot	Yield pounds per acre July 1	Yield pounds per acre July 8	Number of sheep	Forage remaining %
Kentucky bluegrass	1,608	432	2	26.8
Redtop..	1,464	1,152	2	78.7

SUMMARY

Data are presented to support statements regarding the palatability of pasture plants. The increase or decrease of species in a sward is dependent upon competition, environment, and maturity; these in turn condition palatability and therefore the relationship of this latter factor to the animals themselves. Competition eliminates some species, but this is speeded if one species is more palatable than another. Maturity connotes more fiber in a plant and therefore makes for lowered palatability. Environment in general was similar for all species and hence the effect was considered equal.

CERTAIN FACTORS AFFECTING THE GROWTH OF AZOTOBACTER IN THE SOIL

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During the many years which have elapsed since the discovery of the nitrogen-fixing organisms of the genus *Azotobacter*, much experimental work has been done dealing with their nutritional requirements and their probable economic importance in the maintenance of soil fertility. It is generally agreed that *Azotobacter* may, under favorable conditions, be an important factor in the maintenance of soil fertility. It is not definitely known how much nitrogen will be fixed by these organisms under field conditions, but the evidence available indicates that these bacteria may be important in adding to the nitrogen content of the soil and therefore in furnishing growing crops with the nitrogen they need.

The experiments reported here were undertaken to study the influence of various factors on nitrogen fixation by *Azotobacter*, and to determine if possible whether any of these factors can be controlled by artificial means.

In order that one might determine what influence soil treatment had on the occurrence and activity of *Azotobacter*, soil samples were collected from twenty-five experimental fields located in the five major soil divisions of Iowa and representing eleven soil types. These fields had been under observation for many years. Manure had been applied to these soils at the rate of eight tons an acre every four or five years. Lime had been added as needed according to the Truog lime requirement test, while twenty percent superphosphate had been applied at the rate of 160 pounds an acre a year. Composite samples were collected from three plots in each field. One sample was collected from the check plot, a second sample from the plot which had been treated with lime and manure, and another from the plot which had received manure, lime, and superphosphate. These soil samples were tested according to the following methods: by Winogradsky's spontaneous culture test, by nitrogen fixation in solution and on silica gel, by the soluble phosphorous test, by pH determination, and by the Truog lime requirement test.

The results secured indicate that soil reaction is probably the most important factor affecting the distribution of *Azotobacter* in these soils. Different results were secured, however, with the two methods employed for establishing the presence of these organisms. Many of

the soils which gave positive results with the silica gel method failed to show the presence of these bacteria when tested by the Winogradsky spontaneous culture method. The results obtained indicate that the silica gel method is more reliable for testing the presence of *Azotobacter* in soils than the spontaneous method, which is more widely employed. It is our belief that the silica gel exerts some beneficial effect on the growth of these bacteria. On the basis of the Winogradsky test many investigators have concluded that *Azotobacter* do not occur in soils more acid than pH 6.00. In the work reported here, however, these bacteria were detected in soil as acid as pH 5.6.

Many investigators have reported that *Azotobacter* can live in culture media far more acid than pH 6.00 if combined nitrogen is present. Since many of the soils used in this investigation had been manured, there may have been sufficient nitrogen present to support these organisms even though the soils were quite acid. Rather recently some research workers have been able to demonstrate the presence of *Azotobacter* in soils as acid as pH 4.00. From their results it appears that these organisms will live in extremely acid soils if other soil factors are favorable for their growth. In fact, it has been reported that the addition of calcium carbonate to soil may, under certain conditions, inhibit the growth of these organisms. It has been observed that the addition of hydrochloric acid, sulphuric acid, or phosphoric acid to soils which had been limed increased the activity of *Azotobacter* in these soils. Furthermore, some of these research workers have concluded that there is no close correlation between soil reaction and the occurrence of *Azotobacter*, but that the carbonate phosphate ratio is more important than the soil reaction. Other investigators, however, have concluded that the soil complex is the most important factor affecting the occurrence of the non-symbiotic nitrogen-fixing organisms in soils. It is interesting to note that many of the extremely acid soils which contained *Azotobacter* were soils with a relatively high organic matter content. One might assume from the results that soil organic matter contains some factor or factors which stimulate these organisms. In fact, it has been observed that humus and soil extracts from high humus soils will stimulate these bacteria.

It seems that there is no general agreement among research workers concerning the influence of soil reaction on the occurrence of *Azotobacter*. I believe, however, it is safe to say that the majority of evidence available supports the belief that *Azotobacter* are more likely to occur in soils more alkaline than pH 6.00, than in soils more acid than pH 6.00.

It has already been pointed out that in the work reported here many of the soils more acid than pH 6.00 contained *Azotobacter*. In the majority of cases, however, the organisms isolated from these acid soils grew rather feebly on culture media and had a low nitrogen-fixing power. These results seem to indicate that if these bacteria occur in soils more acid than pH 6.00, they are likely to be rather inactive and probably do not fix as much nitrogen as those organisms living in soils with a more favorable reaction.

There is much evidence, therefore, that if enough lime is added to an acid soil to bring the reaction to near the neutral point, and if other soil conditions are favorable, an *Azotobacter* flora can be established without artificial inoculation. These organisms appear to be rather widely distributed, and if soil conditions are made favorable they will probably find their way into the soil by natural means.

In addition to soil reaction there are apparently many other factors which influence the occurrence and activity of *Azotobacter* in soils. Many research workers have found that the soil minerals are necessary for nitrogen fixation by the aerobic non-symbiotic nitrogen-fixers. The bacteria of this group are said to be particularly sensitive to a deficiency of phosphates. There is, however, some difference of opinion relative to the type and quantity of phosphate needed. Many investigators have reported that the addition of phosphate fertilizers to soil had no influence on *Azotobacter*, while others have observed a marked stimulation following the application of such materials. In the work reported here the addition of superphosphate, in addition to lime and manure, did not apparently increase the nitrogen-fixing power of the soil. None of the soils were, however, very low in

available phosphorus. If smaller amounts of soluble phosphorus had been present in these soils, different results might have been secured. The soils which contained *Azotobacter* had a higher average quantity of soluble phosphorus than the soils in which the presence of these organisms was not established. From these data and from many other reports it appears that if farmers followed the soil management methods recommended by their experiment stations, they would, in the majority of cases, provide soil conditions favorable for the aerobic non-symbiotic nitrogen-fixing organisms. In the work reported here sixteen percent of the untreated soils contained *Azotobacter*, while sixty-four percent of the fertilized soils showed the presence of these bacteria. Furthermore, the untreated soils fixed much less nitrogen on silica gel and in solution than did the fertilized soils. It should be pointed out, however, that many of the soils which had a high crop-producing power and possessed conditions which are generally considered favorable for these bacteria, either failed to show the presence of these organisms, or had a low nitrogen-fixing power.

We must admit, therefore, that our knowledge of the conditions necessary for maximum growth of *Azotobacter* is far from complete. Quite recently, many substances have been found which stimulate these bacteria. In addition to ordinary soil minerals, many of the rare minerals, such as molybdenum and vanadium, have been found to stimulate this group of bacteria. In addition to the minerals many organic compounds seem to have a beneficial effect. There is also some evidence that some materials contain accessory growth factors which influence this group of organisms. It is not known just how these materials influence the growth of *Azotobacter* and the nitrogen fixation by this group of organisms, nor is it known what quantities are needed for best results. The answers to many of these questions will have to await further investigation.

THE ROLE OF HYBRIDIZATION IN THE IMPROVEMENT OF THE SOYBEAN

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Most of the varieties of soybeans grown in the corn belt states at the present time have been introduced from the Orient or are selections from such introductions. In the early days of the soybean in this country, thousands of varieties were brought over from Japan, China, and Korea, and subjected to tests in various states to determine their adaptability. The varieties were so numerous and variations so abundant that there was no lack of material for these adaptation trials. Manchu, Dunfield, Morse, Mansoy, Mukden, and many other varieties were thus discovered and increased for commercial planting. This represents the first phase of soybean improvement in this country.

When the introductions and selections had been tested and it appeared that little further improvement could be expected from that procedure, the breeder turned his attention to crossing varieties. In order for any further improvement to be effected, there must be genetic variation for selection to work upon. This is not available in varieties that have come from other varieties by pure line selection. Hence, crossing must be resorted to provide genetic variation.

Technique of Hybridization.—The soybean plant is rather difficult to hybridize due mainly to the small size of the flower. It is advantageous to use a binocular magnifier which magnifies the flower about three times. With the aid of this instrument the anthers can be easily seen and then they can be removed by means of a pair of sharp pointed forceps. Then pollen is brought from the male parent and applied to the stigma of the emasculated flower. From each flower thus fertilized one may expect any number of seeds from none to four provided a pod

develops. One is fortunate if 25 percent of the flowers pollinated develop into pods.

Recently changes have been made in the technique of crossing which speed up the process considerably. The flowers are not emasculated at all but are pollinated without first removing the anthers. When plants are grown from seeds grown in this way it may be found that some of the plants are the result of self-fertilization and therefore not hybrids, but in our experience most of them are hybrids. This technique requires that the parents differ in certain obvious characters, the mode of inheritance of which is known, with the dominant member carried by the male parent so that the hybrids can be identified. Examples of such characters are flower color and pubescence color.

Methods of Handling F_2 Plants.—When the F_1 hybrid plants are allowed to self-pollinate and an F_2 population grown, there are two methods of handling the material from this point on. One is the pedigree system whereby each individual F_2 plant is harvested and threshed separately, F_3 progenies grown separately, and selections made both within and between these and progenies of later generations. If yield of seed is one of the characters in which improvement is sought perhaps early yield tests are justified for the purpose of eliminating many lines as early in the selection program as possible. This idea is based on a study of the combining value of inbred lines of corn by Dr. M. T. Jenkins (1). Using the top-cross method, Doctor Jenkins compared the yields of lines self-fertilized from one to many times and found that the combining value did not appreciably change as the line approached constancy. Applied to soybeans, a self-fertilized crop, the implication is that yield tests of F_3 progenies would be useful in eliminating many strains before much time and effort were spent on them. Such yield tests, however, necessarily involve large numbers of strains. Certain of the newer field plot designs have been worked out by statisticians for the express purpose of increasing the accuracy of tests containing more than the usual number of strains. As an example we have the 15x15 lattice design which accommodates 225 strains.

Another method of handling F_2 material is known as the bulked hybrid method. This is based on the principle that a population of plants derived from a hybrid and continually propagated by self-fertilization tends to become a mixture of pure types with heterozygous types reduced to a negligible proportion. The number of such pure types is given by the expression, 2^m, where m is the number of factors for which the F_1 was heterozygous. Thus with 10 heterozygous factors, we would expect 1024 pure types representing all possible combinations of dominant and recessive members of these factor pairs. The procedure is to thresh all F_2 plants together, plant the seed the next year, or as much of it as is practicable, harvest and thresh all plants together as before, and continue the process for 6 to 10 generations. At the end of that time selections can be made in the population with fair assurance that each plant selected will breed true. During this period natural selection will either eliminate many unadapted types or reduce them to low proportions. Also, at the start the seed can be divided into separate lots and sent to different sections of the state to be subjected to varying climatic and soil conditions. After several generations, it would be expected that the best adapted types would remain in the population in the respective sections, and these could then be isolated, grown in plant rows, and tested further for yield and other characteristics. Many hybrid populations can be carried on in this manner at low cost. In fact, many hybrids can be put together and carried on as one population.

Improvement Through Backcrossing.—Experiments are under way at present to test out the value of backcrossing as a method of improvement. The objectives of this method are (1) to retain the desirable characters of the recurrent parent, and (2) to add other desirable characters from the non-recurrent parent. For example, Illini possesses several desirable characters, as good yield, seed quality, and resistance to shattering; but it has a tendency to lodge. Illini as recurrent parent is crossed to T117 as non-recurrent parent which stands well. The hybrid is then crossed to Illini to make the first backcross. When the progeny is grown the most erect plants are se-

lected and these should be again crossed to Illini to make the second backcross. At this point the recurrent parent makes up 87.5 percent of the gene content, and if the third backcross is made the percentage of Illini germplasm would increase to 93.75 percent. Selection for Illini characters is unnecessary because continual backcrossing to Illini leads to the production of a population that approaches that variety in homozygous condition very rapidly. Illini characters cannot be lost even under non-selection. Selection then is important only in holding the desirable character or characters from the non-recurrent parent.

Success by the method of backcrossing is conditioned somewhat by the mode of inheritance of the characters brought in by the non-recurrent parent. If the inheritance is simple and the character is dominant then selection is easy and success is assured. If, however, the character is quantitative in nature and determined by a large number of genes the problem is difficult. Furthermore, if the character desired is recessive, complications arise. Under such conditions, there are two procedures that might be followed:

(1) Alternate crossing to the recurrent parent with selfing so that by segregation the recessive character will be brought out for selection to lay hold of. After the first backcross, half the progeny will be homozygous for the dominant and half will be heterozygous. These cannot be distinguished. If allowed to self-fertilize, they can be distinguished by the behavior of their progeny, as half will breed true and half will segregate. Those that segregate are the plants desired. The recessive segregates could then be selected and crossed the next year to the recurrent parent, making the second backcross. This procedure could then be repeated.

(2) Continuing the backcrossing without interruption as many times as desired, delaying until the period of backcrossing is completed the isolation of the desired type. As in (1) after the first backcross, half the progeny will be homozygous for the dominant and half will be heterozygous. These of course cannot be distinguished, but a number of them can be crossed back to the recurrent parent again. Theoretically, half of such crosses would be with the homozygous dominant and half with the heterozygous dominant. Hence, the recessive gene cannot be lost even though it is impossible for selection to operate. When the second backcross plants are grown they can again be crossed if desired with the recurrent parent with the expectation however that three-fourths of the crosses will be with homozygous and one-fourth with heterozygous parents. If three backcrosses are considered sufficient the plants can be allowed to self-pollinate, and the next year tested out, plant-to-row, to determine which are breeding true and which are segregating. From the segregating rows, the recessive can be selected with good assurance that they possess most of the contribution from the recurrent parent as well as the desired character from the non-recurrent parent.

Taking Advantage of Hybrid Vigor.—Certain soybean varieties when crossed exhibit hybrid vigor though not nearly to the same extent as corn hybrids. It is generally considered that a hybrid exhibits hybrid vigor if it exceeds both parents in some particular character as yield of seed or height or total weight of dry matter. Corn hybrids made by crossing inbred lines furnish sensational examples of plants that exceed the parent lines in most characters having to do with growth or size. Soybean hybrids do not ordinarily exceed the better parent very much, though there are a few exceptions. A few years ago one of our students, Dr. Collins Veatch, made a careful study of 16 soybean hybrids. (2) Of these, 10 were above the higher parent variety in yield of seed to an extent ranging from 1.58 to 71.53 percent. More recently in a group of 49 hybrids studied by Dr. L. F. Williams, Bureau of Plant Industry, U.S.D.A., at the U. S. Regional Soybean Industrial Products Laboratory, in cooperation with the Illinois Station, there were 32 which were above the higher parent in yield of seed to an extent ranging from 0.1—97.4 percent. These soybean hybrids thus exhibited hybrid vigor just as corn hybrids do, but the difference is in the extent of its manifestation. Compared with the inbred parents many corn hybrids yield from three to five times as much as even the higher yielding inbred. On a percentage basis this would represent an increase of 200 to 400 percent.

There is another very important difference between corn hybrids and soybean hybrids, and that consists in the way they can be utilized for increased production. Because of the flowering habits of the corn plant, corn hybrids can be easily and cheaply produced on a field scale by interplanting the two parents and detasseling the ear parent so that it can be pollinated only by the pollen parent. Thus the commercial crop can be grown from hybrid seed and complete advantage can be taken of any hybrid vigor that may be exhibited. Soybean hybrids, on the other hand, have to be tediously and painstakingly produced by first removing the anthers of the flower borne on the female parent, and then pollinating with pollen collected from the flowers born on the male parent. An expert hybridizer working every day during the pollinating season would do well to produce a few hundred hybrid seeds in this way. It is obviously impossible, therefore, to utilize in the same way as with corn any hybrid vigor soybean hybrids may exhibit.

Consequently, the soybean breeder has to try another method. He must try to hold the increased vigor exhibited by the hybrid while at the same time he carrries the hybrid down through the F_2, F_3, F_4 and later generations allowing self-fertilization to take place each time. The only way in which he can hope to hold the vigor is by selection. But in this he is opposed by the principle of segregation which distributes the favorable factors into different lines. Hence, a compromise results, and the breeder has to be satisfied with whatever vigor he can hold and still have a true-breeding variety.

Convergent Improvement.—The method of convergent improvement which has been suggested for corn also has a place in soybean breeding. This differs from the strict backcross method in that backcrosses are made to each parent instead of but one. Thus two recovered lines are developed which are more nearly alike to the extent that one or more genes have been brought in from the respective nonrecurrent parent, held by selection, and made homozygous by selfing. The hybrid between the two recovered lines should then be homozygous for the new genes which are common to the recovered parents. The hybrid would be expected, theoretically, to exhibit as much hybrid vigor as the original lines when crossed. Hence, when selfing occurs there would be less reduction in vigor because of the increased homozygosity of the hybrid. This method should result in holding at least some of the hybrid vigor which is unavoidably lost under the regular program of crossing following by selection.

A New Variety the Result of Crossing.—Last year a new variety named Chief was introduced to a few growers for further increase. This variety was selected from a cross between Illini and a strain of Manchu. The pedigree system of handling F_2 and later generation plants was used in producing the new variety. Chief is not a hybrid soybean, but a variety which has been selected from a hybrid and which breeds true for its characters. It combines certain of the desirable characters of both parents, but it has lost most of the hybrid vigor exhibited by the F_1. With this as an example of applying the method of hybridization to soybean improvement, it can be anticipated that further work applying the principles and methods above described will lead to still further improvement.

LITERATURE CITED

1. Jenkins, M. T. The effect of inbreeding and selection within inbred lines of maize upon the hybrids made after successive generations of selfing. Iowa State College Jour. of Sci., 9:215-236. 1935.
2. Veatch, Collins. Vigor in soybeans as affected by hybridity. Jour. Amer. Soc. Argon. 22(4): 289-310. 1930.

Papers in Anthropology

Extract From the Report of the Section Chairman

The program at Evanston carried six papers and one panel discussion. Four papers are being published herewith. The titles and authors of the other two and the discussion were as follows:

Walker, Winslow M., *St. Louis Academy of Science, St. Louis, Missouri*—Two Hopewellian Mounds Near Peoria, Illinois. (This is being published by the Illinois State Museum.)

Deuel, Thorne, *Illinois State Museum, Springfield*—Archaeological exploration sponsored by the Museum, 1940-41.

The meeting was attended by a maximum of 26 people, and elected as chairman for the Urbana meeting in 1942 Donald E. Wray, 604 Caroline St., Peoria.

(Signed) F. T. Barloga, *Chairman*

POSSIBLE APPLICATION OF KITE PHOTOGRAPHY TO ARCHAEOLOGY AND ETHNOLOGY

William R. Bascom

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The application of aerial photography to archaeology is no new discovery, but it has thus far been limited to larger sites such as those in the Near East, those of the Maya in Central America, and Zimbabwe in Africa. The fact that this technique has not been extended does not mean that it is not equally useful in the investigation of the less spectacular remains. In the case of village sites, cultivated fields, and even Indian mounds, indeed, the outlines as seen from the vertical axis are often the most interesting and important. The reason is rather that the expense of hiring an airplane and trained photographer or, alternatively, of owning and operating the bulky equipment for balloon photography is almost prohibitive. It is quite possible, however, that aerial photographs may be made from kites with equipment costing only fifty or seventy-five dollars, which is well within the reach of the institutions engaged in archaeological investigations in the Midwest, and with the cost of operation limited to the price of film and development. If such photographs should prove satisfactory, there is no reason why aerial records—both before and during excavation—should not be made of every site.

The applicability of kite photography is not limited to archeology; it may be of considerable importance to ethnology as well in providing an easy method of mapping dwelling sites both among nomadic and settled village peoples, and in recording the layout of farms and garden plots. Aerial photographs have already been used in the latter instance in ethnological work in Africa, but kite photography would make it possible for each institution to have equipment for aerial photographs available for the ethnologists it sends into the field.

In both archaeology and ethnology, furthermore, the kite has a considerable advantage over the airplane in that it can operate at much lower altitudes. By mounting the camera at a considerable distance below the kite, it would be possible to photograph from altitudes low enough to give great detail, and even to use the camera to cover ceremonial activities from the air.

Nor is the idea of taking aerial photographs from kites original either. I believe that it has a rather long history in connection with army observation work. My own acknowledgments, however, must be made to W. Sellers of the Health Department of Nigeria, British West Africa, who described to me the type of equipment used by his department in connection with fever control. Mosquito breeding swamps are photographed from kites before sprinkling them with chemicals.

The camera employed is a light inexpensive folding instrument to which are attached small dry-cell batteries and a solenoid which releases the shutter when the circuit is closed. Actually, since the distances involved are large, a fixed-focus camera of the box type would probably be satisfactory and would be better adapted to the mounting of the necessary accessories. The camera itself is mounted on the cord, some distance below the kite so that it can be rewound and reset after each exposure without having to ground the kite. The switch for the solenoid circuit is mounted on the cord somewhat below the camera in such a way that it can be closed by the pressure of a parachute which is carried up the sting by the wind in the way children send "messages" up to a flying kite. Provision is made so that the parachute is disengaged after closing the circuit, with the result that the circuit is then broken and the strength of the batteries is preserved.

For this work, a folding box kite of the type which can be launched easily in very little wind should be employed. If a small kite of this type is not sufficient to carry the camera equipment, it could be used to aid in launching a larger kite designed to carry most of the burden.

Aside from the advisability of experimenting with different types of kites, there are two main problems to be solved. First, will a simple suspension of the camera be stable enough in the wind, or can another type of mounting be devised so that clear photographs can be obtained? This problem could be partially solved by using a more expensive camera with a high speed shutter. Second, how may the camera be accurately aimed at a desired objective? This will have to be done by flying the kite from a position from which the wind will carry it over the site to be photographed, and perhaps considerable experience will be necessary before this can be done successfully.

It was my original intention to present this paper only after these problems had been solved, and to illustrate it with examples of kite photographs of Indian mounds. But since academic obligations have already postponed this project for three years, I have decided rather to throw the idea open at these meetings and to call for cooperation on it. I am still hoping, however, to do some experimentation in the near future. The fact that kite photography has proved practicable in Nigeria and elsewhere gives me confidence that these problems can be solved.

THE CHICAGO PORTAGE

John B. Ruyle

Champaign, Illinois

In the spring of 1609 near the present town of Ticonderoga, New York, Samuel des Champlain and his allies the Hurons and Algonquin Indians engaged in battle with a group of Iroquois warriors. This battle, the reverberations of which, especially in the Mississippi Valley, were to be felt for decades, changed the course of history.

Champlain with his arquebus was the deciding factor in the battle. It was the first experience of the Iroquois with European firearms and the Indians fled in disorder. As a result of this defeat, however, they became implacable foes of the French at every opportunity. Maps of the early seventeenth century show the English along the eastern seaboard, the Spanish in Florida and on the western coast, and the French occupying territory extending in a line from the Great Lakes eastward along the St. Lawrence.

Due to the geographical location of the French possessions, and the extent of the country controlled by the Iroquois, who were fierce fighters, the French could travel from the Mississippi Valley northward only by the Lake Superior and Lake Michigan routes. Hence the French often used the Chicago Portage whose history came to be closely associated with the exploits of two gallant men, Pere Marquette and Rene Robert LaSalle.

In May, 1673, Louis Joliet, the son of a Quebec wagon maker, and Pere Jacques Marquette, a Jesuit priest, left St. Ignace, in what is now Michigan, to explore for Frontenac, the Governor of New France, and to claim new lands for Louis XIV. They followed the west side of Lake Michigan southward, entered Green Bay, ultimately reaching the Mississippi River. Marquette named this river "Immaculate Conception," a name later to be changed to "The Colbert" in honor of a French minister. The explorers continued south on the Mississippi to the mouth of the Arkansas River; then, fearing to proceed farther lest they be seized by Spaniards, they retraced their route as far north as the mouth of the Illinois River, where upon the advice of friendly Indians, they headed up this tributary, as far as Kaskaskia, the Indian's principal town located near the present town of Utica. After a brief visit here with members of the Illini Confederacy, they returned home after entering Lake Michigan by way of the Chicago Portage. The next year (1674) Marquette, in company with two other Frenchmen and ten canoes of Illinois and Pottawatomie Indians landed at Grosse Point (near what is now Evanston), followed the shore line south to the mouth of the Chicago River, where Marquette became ill, and was detained at the Chicago Portage from December till March 30th. On the return trip to

Green Bay, he crossed the Kankakee-St. Joseph Portage but never reached his destination. He died en route and his body was interred at the mouth of a small river near Ludington, Michigan.

At this time, the fur trade was the most important commercial activity of the new country, and LaSalle dreamed of a chain of forts that could be erected on the principal rivers to control this trade. With this object in view, he hurried to France, succeeded in obtaining a knighthood there and returned with power to colonize the vast unknown empire in America. The first efforts in accomplishing this were the erection of two forts on the Illinois River: Fort Crèvecoeur across from the present town of Peoria, and Fort St. Louis at what is now named "Starved Rock". He made three trips across the Chicago Portage, and, contrary to the belief of Joliet, felt that a canal connecting the Des Plaines and Chicago Rivers would not be a success. All of his expeditions, however, were attended with ill luck and finally, due to a miscalculation of longitude, he failed in his quest for the mouth of the Mississippi. He was assassinated on the Trinity River in Texas, but seven of his followers returned to France, again passing over the Chicago Portage.

From 1700 to 1795, the portage was virtually closed to white men due to the danger of attack by Indians. Then, gradually, travel increased and, from the establishment of Fort Dearborn in 1803 until its extinction in 1812, the portage was once more an important north-south avenue of travel. From the fall of the fort until the close of the Blackhawk War of 1832, the route was little used but after the conclusion of hostilities immigrants from the east began to utilize the Portage. This traffic continued until the completion of a canal in 1848 afforded an easier route, and the Chicago Portage was abandoned.

Glacial Lake Chicago which occupied the present site of Chicago had three stages. In the first, the Glenwood, the water was 55 feet higher, and in the Tolleston (the last stage) 20 feet above the present water level. The Des Plaines River extended then only to Riverside, flowing directly into Glacial Lake Chicago. The outlet of this lake was down the present Des Plaines Valley. When the water receded and a barrier developed near what is now Kedzie Avenue, the Des Plaines reversed its direction and flowed through old Glacial Lake Outlet, leaving a slough a few miles in length between the Des Plaines and Chicago rivers, called Mud Lake. This connected with the Des Plaines by a small stream called Portage Creek. Travellers coming north up the Illinois descended the Des Plaines to Portage Creek, followed this a mile and a half to Mud Lake which was five miles long and one or two miles wide, then skirted its shore for three-quarters of a mile to the Chicago River, which, in turn, lead them into Lake Michigan. At the western extremity of Mud Lake was a small island, one mile in length and half a mile wide which divided it into two channels. The northern channel, the shallower and straighter of the two, was generally used except in dry weather when the deeper, less direct southern channel was followed. On "Tolleston" Beach which fringed the lake on the northern, western and southern sides, ran four Indian trails. The Green Bay trail followed the northern shore, and intercepted two western traces, one of which led to Fullersburg, Downers Grove and Naperville, and the other, southwesterly down the Des Plaines Valley. Along the south side was the Eastern trail which extended eastward and south.

CULTURAL OBJECTS OF CLEAR LAKE VILLAGE SITE

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Clear Lake village site, excavated by the university of Chicago in 1932 and reported by Drs. Cole and Deuel[1], has been further excavated by A. Simpson and G. and E. Schoenbeck, members of the Peoria Academy of Science. Collections have been considerable, mostly from 3- to 7-foot depths. Findings suggest occupation over a length of time by Woodland peoples of changing culture as seems indicated by representative material of five cultural divisions: Red Ocher, Black Sand, Central Basin, Hopewell, and Maples Mills. Cultural continuity might be suggested. The finds support a classification of the Hopewell as an elemental variant, lacking in some of the higher, specialized traits.

Most numerous of the cultural objects unearthed are pottery sherds, which include over 1100 rims, all Woodland, Hopewellian, or grit-tempered wares. Vessel fragments sufficient for projection may number 30 or more, and include Cole and Deuel's types 2, 2a, 3, 3a and 5, as well as a 2½-inch miniature. Finer Hopewell pottery discovered at the site shows similarities with Wisconsin Trempealeau and Louisiana types. Inferior variations of the delicate cross-hatched rim and simulated effects in heavier ware o cur. Resemblances between types 1 and 2a and southern wares are suggested. Type 3a is most abundant and occurs throughout. Additional specimens, in part Hopewellian, are reported, including

Plate I.—Clear Lake Village Cultural Objects. 1. Shell crescent. 2. Grooved net weighter. 3. Y-shaped baked-clay object, purpose problematical. 4. Shale pendant. 5. Bone pendant or gorget. 6 and 7. Two portions clay pipes. 8. Broken shell spoon, hinge removed and edge notched. 9. Bear canine. 10. Bear canine, split and perforated. 11. Elk eye tooth. 12. Elk incisor, grooved for suspension. 13. Bead of cut, hollowed bone. 14. Marine snailshell bead. 15. River snailshell bead. 16. Cut animal jaw. 17. Shaped, notched bone object, purpose problematical. 18. Copper pin.

[1] Cole, F. C., and Deuel, Thorne, *Rediscovering Illinois*, University of Chicago Press, 1937.

a thickened-lip, red-painted ware and a concentric trail type.

Bone objects, well preserved, include 111 awls, 23 2-pointed implements of split cannon bone of deer, beamer, bodkin, spatula, 2 types of beads, game bones, a pendant, a chisel-ended tool, a beveled-end tool, and others. Worked horn items are: a socketed handle and tips, cut, hollowed or grooved. Other animal remains are an elk eye tooth, elk incisors, bear canines, cut animal jaws, sheepshead otoliths, a turtle carapace bowl, fish spines (some polished from use), and drumfish toothplates. Refuse bones are abundant. Burials include 2 children, 1 dog, and a bundle burial.

Shell items are: hoes, spoons, marine and river snailshell beads, a crescent, a cache of 400 snailshells, hundreds of opened clamshells, and others.

Stone tools include 5 celts, grooved sharpening stones, a grooved net weighter, anchor(?), sandstone knife, 1 pendant and fragments, rubbing-, hammer-, pitted- and peckingstones. Limonite tools are: 2 spades, celt, knife, and fragments.

Flint articles found at the Clear Lake site consist of 42 points, mostly notched; 12 knives (flake, spawl, triangular, and asymmetric); 53 scrapers (end, spawl and flake); drill fragments, and spheroidal nodules.

Vegetable material is comprised of a carbonized corncob fragment, carbonized hickorynuts and acorn kernels, with some charcoal and ash.

Other items are: bits of muscovite, a copper pin, portions of clay pipes, Y-shaped baked-clay object of problematical character, volcanic tuff, red ocher, and broken slabs of saucer-shaped ground-basins (?) made of a hardened clay and sand mixture, smoothed above and merged with sand below; occasional accumulations of stones, one containing more than 50 stones.

MIDDLE MISSISSIPPIAN ~~GRIT~~ TEMPERED WARE

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I wish to draw attention to a peculiar type of pottery which occurs in certain Middle Mississippian sites in central and southern Illinois. This type differs from the ordinary Mississippi ware in a number of significant traits. The vessels are ~~grit~~ tempered, intensely fired and have rough undecorated or cord marked surfaces. They occur in the forms of shallow conical vases with two straight legs at the base, elongated cylinders and pedestal or boot shapes with flaring lips, mushroom bases and with narrow interiors and heavy walls. These vessels are quite rare but seem to have a wide distribution. The conical form is known to the writer by two specimens from the Kingston Lake site and one from the Crable site. The cylinder is represented at Kingston by the sherds of two vessels. The pedestal has been described by Titterington in his monograph on the Cahokia site.

The conical vessel from Kingston Lake is 6½ inches in diameter, 3½ inches tall and has walls ⅜ of an inch thick. It is brick red and apparently cracked and sagged before baking. The temper is of about medium coarseness compared to other grit tempered pottery in this area. Since the vessel has only two projections or legs it can not be stood up by itself. (Fig. A.) This type is not to be confused

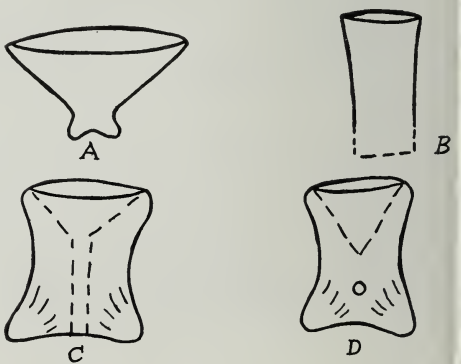

PLATE I.—DIAGRAM OF UNUSUAL MIDDLE MISSISSIPPIAN GRIT TEMPERED WARE. **A.** Conical vessel from Kingston Lake. **B.** Cylinder from Kingston Lake. **C.** "Boot" from Cahokia site, vertical perforation, after Titterington. **D.** "Boot" from Cahokia site, transverse perforation, after Titterington.

with the three-or four-legged pots which are fairly common in the Middle Mississippi culture and have shell tempering and generally are polished or smoke finished. The cylinder from Kingston, as projected from the sherds, is seven inches in diameter and at least 14 inches in length, (fig. B). The rim is square in cross section but no trace of the base is present. The surface has been carelessly finished and tempering is either absent or very fine grit.

Titterington has described the boot or "pedestal" in his monograph on the Cahokia Mound Group. Thirteen fragmentary pieces are known from the Cahokia site, all a well fired crumbly ware, with coarse grit temper. Seven show coarse cord marking, and two a rather fine cord marking. There are two types, both with a flaring top and two foot-like projections placed almost at right angles to each other so that about three-fourths of the base is roughly circular. Both types have a deep inverted conical cavity, the base of the cone being at the top and the apex extending one-half to two-thirds of the way down through the object. The difference in the types is in a hole in the base of the pieces. In the first type the hole is an extension of the conical cavity downward to emerge on the bottom of the object (fig. C). In the second type the hole goes through the base horizontally and has no connection with the cavity above (fig. D). This specimen is five and one-fourth inches high, and the rim diameter is three and three-fourths inches. The rim varies from five-eighths to three-fourths of an inch in thickness, and the hole is three-eighths of an inch in diameter.

In a letter Titterington adds that similar vessels were described in an old journal of a society in Kansas City. He says that all the specimens that he has found have been on village sites where a very high percentage of all other materials was Mississippian rather than Woodland. However he is not certain that the boots should be called Mississippian.

Griffin also hesitates about assigning this type to the Mississippian because of the presence of cord wrapped paddling on the boots and the fact that the type has not been found on many of the sites related to Cahokia. He is also not convinced that the pottery from Kingston Lake and Crable is the same as Titterington's boots from Cahokia. I feel, however, that the basic pattern of the boots and the Kingston conical vessel is the same. Both have a conical interior or cup with two projections or legs at the base. The Kingston form might very well be a simplification of the Cahokia type.

The case for these objects may be summarized as follows: They are products of the Middle Mississippi culture because they are found only on Middle Mississippi sites and their form and decoration bear no resemblance to the pottery of other cultures so that they can not be explained as intrusions from a Woodland group; in tempering, shape, surface treatment and firing they are widely differentiated from the typical utilitarian pottery of the Middle Mississippi; their occurrence is too rare for them to have had any common function (it has been suggested that the cone might have been a cover for a pot); the unusual quality of the pottery argues against any common use; the careless execution of the vessels indicates that they were not intended for continuous use but for a temporary or occasional use. It is unlikely that it represents funerary pottery since all recorded specimens have come from village deposits and not from burials. All these considerations would seem to indicate that this peculiar pottery type may represent a ceremonial ware of the Middle Mississippian culture. No such ware has yet been recognized but we might suspect its existence from the presence of the "Pyramid complex" which indicates an elaborate ritual life.

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Titterington, P. F.—"For Identification", *American Antiquity* Vol. 3, April, 1939, page 354.
The Cahokia Mound and Village Site, p. 13.

Papers in Botany

Extract From the Report of the Section Chairman

The Botany Section carried 25 papers, 20 of which are herewith published. The others were:

King, Lawrence J., *University of Chicago, Chicago*—Preliminary studies of the effects of growth substances and light intensities on *Anacharis densa*.

Olmsted, Charles E., *University of Chicago, Chicago*—Some aspects of plant interrelationships in an oak-maple forest.

Romig, John R. and F. Lyle Wynd, *University of Illinois, Urbana*—The effect of nitrogenous fertilizer on the vitamin C content of cereal grass leaves.

Scully, Norbert J., *University of Chicago, Chicago*—Preliminary investigation of root distribution in an oak-maple forest.

Voth, Paul D., *University of Chicago, Chicago*—Growing *Marchantia polymorpha* on glass cloth with controlled inorganic nutrients.

The chairman was re-elected for the Urbana meeting in 1942.

(Signed) Paul D. Voth, *Chairman*
Dept. of Botany, University of Chicago

SEED FORMATION, GERMINATION, AND POST-GERMINATION DEVELOPMENT IN CERTAIN CICHORIEAE

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ABSTRACT

Part I. Fruit Development—Parthenogenesis. Hundreds of flower heads of *Taraxacum officinale* Weber, *Chichorium intybus* L. and *Lactuca ludoviciana* (Nutt.) Riddell were castrated by means of a razor blade so as to remove the anthers and stigmas. Castrations were made between 6 and 7 A. M. before the one-day flowers opened. Removing stamens and stigmas of *Chichorium intybus* with the fingers was the best method of castration.

Seeds of castrated and normal flowers were germinated at 26.66°-32.22°C. and 9°C. At 9°C. 25% of the *Taraxacum* seeds germinated while 45% germinated at room temperature. Seeds of castrated *Chichorium intybus* and *Lactuca ludoviciana* did not germinate at room temperature but normal fertile seeds gave from 4-18% and 16-56% germination respectively.

Conclusions:—1. The results of Stork, Raunkiear, Sears, Ikeno, Osawa, and others in producing parthenogenesis in *Taraxacum* has been confirmed. Parthenogenesis is the normal manner of seed development in many species of *Taraxacum*. 2. Parthenogensis apparently does not exist in *Lactuca ludoviciana* or *Chichorium intybus*.

Part II. Seed Germination.—It has been found by a number of investigators that the seeds of different species of cultivated lettuce are affected in different ways by light, oxygen, moisture, temperature, and chemical factors before and during germination. It was the object of these experiments to determine the factors influencing seed germination and dormancy in *Lactuca scariola* L. and *Lactuca ludoviciana* (Nutt.) Riddell seeds. Seeds of various ages were treated by germinating at various temperatures, germinating under different moisture conditions, exposing to artificial light and sunlight, mutilating seeds, and soaking in chemical solutions. Treated seeds were placed on clay germination blocks made for this purpose by the Ceramics Department of the University of Illinois or between filter paper in Petri dishes. Air-dry seeds used in these experiments were 12 months, 10 months, 8 months, and 2 to 24 days old. Controls were used for seeds germinated at temperatures of 7°-8°C., 8°-20°C., 23°-25°C., 26°-30°C., and 36°-50.5°C. Eight months-old seeds of *L. ludoviciana* in water and air-dry were placed at -7°C. for 2, 5½, 8, and 24 hours. They were germinated at 15°-24°C. The same age seeds were soaked in the dark for 5, 22, 48, and 77 hours at 3°-7°C. then germinated at 18°-24.5°C. The same age seed were soaked in the dark for 5, 15, 24, and 30 hours at temperatures of 8°-23°C., 15°-20.5°C., 18°-22°C., and 42°-51.5°C. then germinated at 18°-24.5°C. The longer the seeds were soaked at -7°C. the lower the percentage of germination. The longer the seeds were soaked at 3°-7°C. the higher the percentage of germination, increasing from 30%-65% for the 5 and 77 hours soaked. Seeds soaked at 8°-23°C. and germinated at 18°-24.5°C. averaged 66% for all hours soaked. Eight month old seeds of *L. scariola* were soaked 24 hours at 8°-20°C., 15°-22°C., 23°-24.5°C., and 40.5°-48°C. then germinated at the same temperature. With the exception of those germinating at 15°-22°C. all were exposed to diffused light during soaking and germination. The same age seeds were placed in an oven at a temperature of 36°-50.5°C. for 1, 2, 3, and 5 days, then germinated at 15°-22°C. The percentage of germination was inversely proportional to the temperature. Both dry and soaked seeds germinated 70% at the lowest temperature.

Exposure to sunlight for five minutes increased the percentage of germination of 24 day old *L. ludoviciana* seeds that had been soaked 2 hours.

Eight months-old seeds of both species of wild lettuce were exposed in water and dry to a 75 watt Mazda bulb at a distance of 3 feet for 5, 10, 20, 40, and 60 minutes. An aluminum reflector was used above the bulb and an electric fan was directed upward on the bulb to dispense with as much heat as possible. The seeds were placed on clay blocks for germination at a temperature of 24°-32°C. The increase in exposure to light did not seem to increase the percentage of germination but germination was increased from 0-30% for *L. ludoviciana* seeds in water. *L. scariola* were not definitely affected by this treatment.

Ten month-old seeds of *L. scariola* were soaked for 1, 2, 3, 4, 5, and 6 hours. Forty seeds were placed on a clay block in the germinator each hour and half of these were covered with a strip of filter paper dipping into the water. The germination temperature was 23°-25°C. The same age seeds were soaked 3, 6, 9, and 18 hours, then germinated at the same temperature. It is evident that the seeds imbibe enough water for germination within an hour and additional soaking decreases the percentage of germination from 7-3% over a period of 6 hours.

Thirteen day-old, 10 month-old and 12 month-old seeds were soaked a half hour and the rounded ends cut off. After 12 hours the seed coats were removed from other seeds and all were placed on sand depths of 2, 3, 4, and 4⅜ inches in an apparatus designed by Prof. C. F. Hottes for maintaining a constant amount of water in each depth of sand. The percentage of water varied from 7.85-14.05 and was inversely proportional to the depth of sand as was the percentage of germination. On two-inch sand substratum 85% of the seeds with rounded ends cut off germinated while 35% of the seeds with testas removed germinated.

A hundred 10 month-old air-dry seeds of *L. scariola* were placed on a clay block at 23°-25°C. for germination. Only 3% germinated in 13 days. The seed coats of 20 of these seeds were removed at the end of 13 days and returned to the clay block. At the end of 29 days the seed coats of 20 more seeds were removed and returned to the clay block. None of the remaining seeds germinated but 80% of the naked embryos germinated. Fresh seeds of *L. scariola* were placed on a clay block at 23°-25°C. The seed coats of 20 seeds were removed on the 2nd, 4th, 7th, and 9th days. The same treatment was given 12 month-old seeds of *L. scariola* and *L. ludoviciana*. 90% of the 12 month-old *L. scariola* seeds germinated when the testas were removed at the end of 2 days on a clay block but only 50% germinated when the testas were removed on the 7th day. Only 5% of the control germinated in the two species. Fresh *L. scariola* seeds were soaked in water for 4, 6, 8, 10, 12, 14, 16, 18, and 20 hours. 40 seeds were removed at the end of each period. Testas were removed from 20 seeds and all were placed at 23°-25°C. Seeds imbibed enough water for maximum germination, 30%, after soaking 4 hours and removing testas. An after-ripening period seems necessary before complete germination occurs. The average for the controls of this age seed was 11.6%. The rounded ends of 8 month-old air-dry seeds of both species were cut off and placed on a clay block at 15°-24°C. 30% of the *L. scariola* germinated while 10 month-old seeds treated in the same manner gave a 95% germination at 23°-25°C. 45% of the *L. ludoviciana* germinated as compared with 5% for 10 month-old seeds at the same temperature. Fifteen day-old seeds of *L. scariola* germinated 5% and *L. ludoviciana* 2% at 23°-25°C. after the ends were cut off. It is evident that 10 month-old *L. scariola* seeds are not dormant but that the testas inhibit germination. It is evident that the 15 day-old seeds are dormant.

Ten month-old seeds of *L. scariola* were soaked from 9½-18 hours in solutions of Hormodin varying from .25cc. of Hormodin per 100 cc. of water to .046875 cc. per 100 cc. of water. They were germinated at 23°-25°C. on clay blocks. Seeds soaked for 9½ hours in .09375 cc. of Hormodin per 100 cc. of water gave the highest percentage of germination, 25%. In general the percentage of germination was inversely proportional to the hours soaked. Fourteen tests resulted in no germination in 18 days.

Five month-old seeds of *L. scariola* and 7 month-old seeds of *L. ludoviciana* were shaken in a vial with Rootone then placed on a clay block at 19.5°C. The average germination for *L. scariola* was 11% while the controls averaged 22%. Treated seeds of *L. ludoviciana* gave a 10% germination while the control showed a 5% germination. Hormodin

and Rootone decrease germination of wild lettuce seed rather than increasing it as some investigators have found for various seeds.

Conclusions.—1. Freshly harvested seeds of *Lactuca scariola* are dormant. The removal of seed coats does not alter their dormancy. The embryos evidently must experience a period of after-ripening before they can germinate. 2. The embryos of *L. scariola* seeds lose their dormancy within 8 to 12 months after the seeds are produced and are then capable of germination. 3. Eight month-old *L. scariola* seeds give a higher percentage of germination than older or freshly harvested seeds at the same temperature. 4. Prechilling at 3°-10°C. causes an increase in the rate and percentage of germination of *L. ludoviciana* and *L. scariola* seeds at higher temperatures, 20°-30°C. Freezing temperatures caused a decrease in the percentage of germination of *L. ludoviciana* seeds. 5. Temperatures between 10°-20°C. are more favorable for germination of air-dry *L. scariola* and *L. ludoviciana* seeds of various ages. 6. Probably moist fresh *L. ludoviciana* seeds are affected more by exposure to light than older seeds. 7. Moist and dry seeds of *L. scariola* are evidently not influenced by exposure to light. 8. The growth promoting substances, Hormodin and Rootone, did not show evidence of increasing the rate or percentage of germination of seeds of *L. ludoviciana* and *L. scariola.*

Part III. Photoperiodism.—On February 25, seeds of *L. scariola* with the ends opposite the radicle cut off were placed in each of 12 pots of earth. Four of these pots were placed on a clinostat under electric lights of 3000 watts, providing continuous light. The second group of four pots were allowed only 7 hours of daylight. The other four pots were used as a control under the same conditions but allowed normal daylight. The temperature averaged 20°C. during the winter and never went above 35°C. during the spring and summer.

Two months after the seeds were planted the continuous-light plants ranged in height from 8-26¾ inches and had 4-10 well developed leaves. Short-day plants did not have stems but merely a rosette of leaves that varied from 1½-3 inches in length. The normal-day plants had larger rosettes with leaves 3½-5 inches long but no stems. All of the short-day plants died within 4½ months. The continuous-light plants grew to a height of 34-50 inches, flowering 3 months after planting, with seeds maturing 15 days later. Normal-day plants ranged from 8-20 inches in height in 5 months, with flowers 10 days later and seeds matured in 15 days. The internodes of the continuous-light plants averaged 2½ inches while those of the normal-day plants averaged ¾ inch in length. The continuous-light plants did not form a rosette as was the case in short and normal-day plants.

Conclusions:—1. *Lactuca scariola* matures and produces seeds in a shorter time under continuous light than under normal daylight in a greenhouse. 2. Under normal light *L. scariola* remains in a vegetative condition longer than under continuous light. 3. *L. scariola* is a long-day plant.

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GERMINATION AND SEEDLING GROWTH-FORM OF TWO HUNDRED WEEDS

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The selection of plants in this study is based wholly upon the 683 dicotyledonous herbaceous weeds listed by the following authors: Georgia[3], Muenscher[4], Clark and Fletcher[2], Runnels and Schaffner[6] Beal[1], and Pammel[5]. Seeds of 233 species were gathered in the field to insure their freshness and maturity.

Seeds were planted in flats out-of-doors during the winter. Replants were made in summer either after the seeds had had a week of refrigeration or with no previous treatment. Of the 233 species planted, the following 11 failed to germinate: *Teucrium canadense*, *Ellisia Nyctelea*, *Heracleum lanatum*, *Prenanthes racemosa*, *Stachys* sp., *Triosteum* sp., *Eupatorium purpureum*, and *Solidago graminifolia*. *Lithospermum canescens* failed to sprout even after refrigeration and treatment with concentrated acid. Germination percentage in *Convolvulus sepium* was negligible. *Galium asprellum* and *G. aparine* repeatedly failed of germination in winter plantings although a late summer planting of the latter (after a week of refrigeration) sprouted.

Two species of the genus *Urtica* germinated feebly and the seedlings were so delicate that, although tended carefully, the tops were only 1.5 centimeters high in September. *Salsola Kali var. tenuifolia*, *Mollugo verticillata*, and *Portulaca oleracea* germinate tardily.

There is apparently no one seedling character that distinguishes an entire family; in fact, there is often lack of constancy within a genus. However, in 8 genera of Labiates investigated, all cotyledonary leaves have narrow basal lobes directed toward the petiole. The characteristic obreniform cotyledons of the genus *Brassica* are not duplicated in 10 other genera of Crucifers. Of the Legumes studied only *Vicia* and *Lathyrus* have hypogeal cotyledons.

The petiolar portions of the cotyledons of many seedlings are connate to a degree that results in a structure that ranges from a shallow rim to a 2.5 centimeter tube. This character may be prevalent in a family or genus but not constant. Twelve out of thirteen species of Polygonaceae have this feature. It is scattered through various families having its greatest frequency and size in the Tribe Heliantheae of the Compositae.

Commonly the cotyledons wither and cling to the seedling until its growth dislodges them. In some species abscission is sharply defined. In five Solanaceous species the cotyledons absciss leaving a neat, somewhat elevated semilunar scar. In 11 species of Legumes with epigeal cotyledons, only *Amorpha* and *Melilotus* abscissed with a clean-cut scar. Or the blade may absciss leaving a persistent petiolar stub. Of the seven species with this characteristic, 3 were in the Figwort family.

The above ground cotyledons of *Lupinus*, *Amorpha*, *Tephrosia*, *Desmodium*, and *Galium* maintain their fleshy condition and become foliaceous. *Gaura parviflora* has a large and fleshy peg in germination. Doubtlessly this structure is present in at least one other related species but has been overlooked.

Leaf folding in vernation may be loose and indefinite. In the Polygonaceae the halves of the leaf are tightly revolute, the two rolls in close apposition on the abaxial face of the leaf. Leaves of *Solidago*, *Aster*, and *Silphium* are strongly convolute in vernation. When the juvenile leaves are simple or lobed as precursors of the mature divided or compound leaves, the earliest leaves anticipate the later ones in their habits of folding. The principal veins are most distant from the axis, the intervening parenchyma, lobe, or leaflet edges proximal to the axial line.

The seedling leaves presage the nature of the adult leaves. In *Trifolium*, *Melilotus*, and *Medicago* the first leaf is unifoliate, the succeeding leaves trifoliate. In *Amorpha*, *Tephrosia*, and *Desmodium* at least the first five leaves are unifoliate. In these Legumes the unifoliate leaf blade

is articulated upon the petiole. The first leaf of Oxalis has three leaflets. In ten Ranunculaceous and Rosaceous species of five genera the first leaves are crenate or scarcely lobed. In succession the progressively deepening divisions lead to the adult form. In three genera of Umbellifers the first leaf is compound, in three others merely lobed or parted. There is a common pattern of development in *Achillea*, 3 species of *Anthemis*, *Matricaria*, and two species of *Artemisia* that progresses from tridentate to pinnately divided leaves.

Seedling leaves are often interpreted as paired when later leaves are alternate. In five genera of Cruciferae there are species in which the first and second internodes are so shortened as to appear non-existent. In five genera of Chenopodiaceae the second, fourth, and sixth internodes are more or less obsolete. The resulting two members of such a "pair" of leaves are not connected by a nodal line or rim and ridges or striations of the stem are continuous between the leaf insertions. By the same criterion, the lower leaves of *Portulaca*, *Polanisia*, *Desmodium*, *Xanthium*, and some species of *Helianthus* are not paired. In three species of the genus Euphorbia the lower pairs of leaves are united by nodal rims although later leaves are alternate. The first two leaves of *Matricaria suaveolans* diverge from a common node and the petioles are connate for an appreciable distance. All later leaves are alternate.

The seedling growth-habit may be expected to foreshadow the adult form. The life-form of a caulescent plant with a basal rosette of leaves is often determined independently of environmental conditions as in *Verbascum*, *Ranunculus*, and the Umbelliferae in general. *Veronica peregrina*, *Lappula echinata*, *Lactuca scariola*, *silene antirrhina*, and *S. noctiflora* are rosette-form in late summer germinations and caulescent in spring. This plasticity in growth-form is excelled by certain Cruciferae. *Thlaspi arvense* and two species of *Lepidium* germinating in spring manifest reduced or lengthened internodes depending upon whether or not they are growing in competition.

If the tap-root of the mature plant is not dominant, its dwindling significance may be observed in the seedling. Of the 19 rosette-form seedlings in which adventitious roots emerge from the stem and soon outstrip the tap-root, 17 were plants of damp habitats. In contrast, *Galium Aparine* with a vigorous four-centimeter tap-root at the time of the appearance of the cotyledons, has a frail and tenuous root at maturity.

Contraction of the hypocotyl is usual in rosette plants with strong tap-roots. Similar telescoping takes place in caulescent *Phytolacca decandra* and *Oxybaphus nyctagineus*.

Summary

The time and manner of germination of 222 species of weed seeds was observed. Another 11 species failed to germinate. Growth-forms of the developing seedlings were recorded.

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RELATION OF THE EFFECTS OF SEED WEIGHT TO ROOTS AND TOPS OF TWO VARIETIES OF SOYBEANS

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A survey of the literature gives evidence that considerable work has been done on the relation of seed weight to various phases of vegetative and reproductive plant growth. Little or nothing, however, has been done concerning the effects of seed weight on the relation between tops and roots. Also the effects of variation in seed weights to dry weight of tops and dry weight of roots has not been studied in detail.

The object of the present experiment was to investigate the relation between:

1. Seed weight, and dry weight of tops and dry weight of roots when variation in seed weight is small.
2. Seed weight, and dry weight of tops and dry weights of roots when variation in seed weight is greater.
3. The dry weight of tops and the dry weight of roots of plants, when the plants are grown from seeds of different weight groups.

Seeds of each of the two varieties of soybeans, *Soja max.* Piper var. Biloxi and Mandarin, were separated into three groups designated by the letters A, B, and C. The seed coats were removed in all cases because they are not available as a source of food for plant growth and play no part in photosynthetic activity. In the seeds designated by the letter A none of the food storage tissue was removed; in those seeds designated by the letter B approximately half of one cotyledon was severed; and in those seeds designated by the letter C one whole cotyledon was cut off. The seeds were then weighed accurately to one-tenth of a milligram.

The seeds were planted in sterilized, well mixed loam soil in 4½ inch pots. The pots containing the seeds were watered daily with sterile tap water until the epicotyls had appeared above the surface of the soil, after which time they were watered with unsterilized tap water. Watering of all plants was controlled and equalized as far as possible.

Fifty plants were used for each of the three sets, making one hundred fifty plants for each variety. The plants were taken down at the time the first flowers appeared; they were then cut at the collar and the tops and the root systems were individually reduced to oven dry weight and weighed to one-tenth of a milligram.

Table 1.—Weights and Correlation Coefficients

Av. Dry Wt. Grams	Biloxi Soybeans				Mandarin Soybeans			
	A	B	C	ABC	A	B	C	ABC
Seed Weight...	0.2466	0.1859	0.1247	0.1835	0.1472	0.1246	0.0956	0.1296
(Standard Deviations)..	±0.0262	±0.0211	±0.0185	±0.0546	±0.0127	±0.0108	±0.0100	±0.0259
Top Weight....	1.8901	2.0001	1.5499	1.7980	0.7286	0.5519	0.3160	0.5322
Root Weight...	0.1732	0.1962	0.1422	0.1710	0.1240	0.0945	0.0587	0.0924
Growth Period (Days).....	35	35	35	35	30	30	30	30
Correlation Coefficients								
Seed Wt. with Dry Wt. of Tops.....	0.2466	—0.0156	—0.0676	0.3337	0.0687	—0.2482	—0.1186	0.6578
Seed Wt. with Dry Wt. of Roots.....	—0.0757	—0.1686	0.0401	0.1287	—0.0301	—0.0013	—0.2950	0.4709
Dry Wt. of Tops with Dry Wt. of Roots.....	0.2583	0.4732	0.3125	0.4879	0.4157	0.7713	0.6944	0.8082

Correlation coefficients were determined from the formula:

$$C = \frac{Sxy}{\sqrt{(Sx^2)\ (Sy^2)}}$$

in which C represents the correlation coefficient, x the deviations of the seed weights from the average, and y the deviations of the plant (top and root) weights from the average. A coefficient between 0 and plus 1 indicates a positive correlation; a value between 0 and minus 1 indicates a negative correlation. In this paper a negative correlation is indicated by a minus sign, a positive correlation by no sign. Table I gives the results.

The results of this experiment may be summarized as follows:

1. There is generally a higher correlation value between seed weight and dry weight of tops than between seed weight and dry weight of roots.

2. The value of the correlation coefficients between seed weight and the dry weight of tops or between seed weight and the dry weight of roots appears to be greater with a larger variation in weights among the seeds of a group. (Standard deviations from the mean seed weight and correlation coefficients of groups ABC as compared to standard deviations and correlation coefficients of groups A, B, and C. See table I).

3. The correlation value between the dry weight of tops and the dry weight of roots is higher when the plants are grown from lighter weight seeds (C or B as compared to A). The highest correlation values, however, exist when the plants from groups A, B, and C are considered as one group, i.e., group ABC.

EFFECT OF LENGTH OF DAY AND TEMPERATURE ON THE OPENING OF BUDS OF DORMANT TWIGS

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There have been a number of theories advanced as to the causes of dormancy in perennial plants. It was at one time supposed that dormancy in winter and growth in spring and summer were regulated by an inherent rhythm in the plant, but it is now well established that the expression of this cycle is subject to environmental factors as well as to inherited ones. Length of day (6, 9) has been found to be an important factor both in the initiation and in the breaking of dormancy, in which cases a short photoperiod hastens the initiation of dormancy and a long photoperiod hastens the breaking of dormancy. In some cases (7) high temperatures are sufficient to break dormancy in woody species. Many woody plants will remain dormant long after favorable growing conditions have begun unless they have been subjected to a cold treatment during their dormant period (2, 5, 8). Several chemicals (as ethylene chlorhydrin, ethylene dichloride, chloroform, ether, ethyl bromide, and ethyl iodide) have been successfully employed in breaking dormancy in advance of the usual time (1, 3, 4, 7, 8, 10).

In these experiments a study was made of the effect of day-length and temperature on the opening of buds of dormant woody stems. Uniform cuttings of Lilac, (*Syringa hybrida*); Red-Osier Dogwood, (*Cornus stolonifera*); Snowball, (*Viburnum opulus*); and Hawthorn, (*Crataegus sp.*) were collected February 3 and brought into the greenhouse. They were placed in sand which was kept moist by adding tap water and were subjected to four different conditions of temperatures and length of daily illumination: (1) long-day, high temperature, (2) short-day, high temperature, (3) long-day, low temperature, and (4) short-day, low temperature. The short-day period was that of the normal day length of February which was about 8½ hours. The long-day plants received 16 hours of daily illumination. They were given additional light by means of 2000 watt electric flood-lamps. The high temperature plants were placed in rooms regulated at about 21° C and the low temperature rooms were regulated at about 10° C. The temperatures varied somewhat depending on the amount of sunshine, but not more than about 3° C. Daily observations were made and the data on the opening of the buds and the unfolding and growth of the leaves are given in Table 1.

Both day-length and temperature had an effect in breaking dormancy and on growth of cuttings of Lilac, Dogwood and Snowball. Hawthorn responded only to temperature and not to length of day. Temperature in all cases had a greater effect than did day-length. At the same temperature the buds under long-day conditions opened from 1 to 4 days sooner than those under short-day conditions. Under the same day-length conditions however, those at high temperatures opened from 5 to 9 days earlier than those at low temperatures. Lilac and Snowball at high temperatures opened their buds 1 day earlier under long-day conditions than under short-day conditions, and Lilac started to unfold leaves 3 days earlier under long-day conditions. Lilac, Dogwood, and Snowball all had larger leaves under long-day conditions. At low temperatures Lilac, Dogwood, and Snowball opened their buds from 2 to 4 days earlier under long-day conditions than under short-day conditions. Under long-day low temperature conditions all three species unfolded their leaves after 12 to 17 days, but under short day low temperature conditions none of the twigs put out leaves.

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TABLE 1.

Condition	Plant	Number of days required for buds to open	Number of days when leaves first emerged	Number of days when leaves were fully emerged	Length of leaves 22 days after experiment was started (cm.)
Long-Day High Temperature	Lilac.....	3	5	8	2.0–2.5
	Dogwood..	8	9	11	1.5–2.0
	Snowball..	5	8	10	2.5–3.0
	Hawthorn.	10	14	17	0.5–1.0
Short-Day High Temperature	Lilac.....	4	8	9	1.0–1.3
	Dogwood..	8	10	13	1.0–1.5
	Snowball..	6	8	11	1.5–2.0
	Hawthorn.	10	15	17	0.5–1.0
Long-Day Low Temperature	Lilac.....	8	12	17	0.7–1.0
	Dogwood..	14	17	18	0.5–0.9
	Snowball..	10	16	19	0.5–0.7
	Hawthorn.	No response	Leaves not emerged	Leaves not emerged	.....
Short-Day Low Temperature	Lilac.....	10	Leaves not emerged	Leaves not emerged	.....
	Dogwood..	17	”	”	.....
	Snowball..	14	”	”	.....
	Hawthorn.	No response	”	”	.....

SOME MINERAL DEFICIENCY SYMPTOMS IN PLANTS

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In addition to carbon, hydrogen, and oxygen, plants need a number of mineral elements for normal growth and development. If any of these essential elements are not available to the plant, certain disturbances and usually characteristic deficiency symptoms result (1, 2, 4, 5, 7, 9, 10, 11, 14, 15, 17, 19). These essential elements are applied in the form of nutrient solutions made up of various salts (3, 6, 8, 12, 13, 16, 18). By choosing various combinations of salts any one of the elements may be absent in these solutions and such solutions are used to study deficiency symptoms.

In these experiments some mineral deficiency symptoms of three flowering plants were studied. The following plants were used: *Petunia hybridia*, var. Rosy Morn; *Salvia splendens*, var. Scarlet Dragoon; and *Phlox drummondii*. The plants were grown in clean quartz sand in two-gallon glazed earthenware pots. Nine series of each of the four plants were grown, consisting of one series which received a complete nutrient and eight series each lacking a different element. The eight deficiencies were: nitrogen, calcium, potassium, phosphorus, magnesium, sulphur, boron, and iron. The nutrient solutions were made up with distilled water and Merck's reagent quality chemicals as indicated in Table 1.

Deficiency Symptoms

The Complete Nutrient Plants.—The plants in this series were green, vigorous, and made good growth in general. All produced many flowers.

Nitrogen Deficiency.—The minus nitrogen plants were all stunted, spindling, pale in color, and very hard rather than succulent. The lower leaves particularly were yellow and finally dried and fell off. All the leaves were much reduced in both size and number. One Petunia plant in the nitrogen deficient series produced a flower and it bloomed eight days earlier than did the plants of the complete nutrient series. The top-root ratio of the minus nitrogen plants was much smaller than that of the complete nutrient plants.

Calcium Deficiency.—The calcium deficiency symptoms were the most severe of all the deficiency symptoms. Petunia

Table 1.—Composition of Nutrient Solutions

	Constituents of Solutions
Complete Nutrient	$Ca(NO_3)_2$ .....0.006 molar KH_2PO_4 .....0.0045 molar $MgSO_4$ .....0.045 molar B .....0.5 p.p.m. added as H_3BO_3 Fe .....0.5 p.p.m. added as ferric citrate Mn .....0.5 p.p.m. added as $MnCl_2$ Cu .....0.125 p.p.m. added as $CuCl_2$ Zn .....0.5 p.p.m. added as $ZnCl_2$
Minus Nitrogen	$CaCl_2$ Substituted for $Ca(NO_3)_2$
Minus Calcium	$NaNO_3$ Substituted for $Ca(NO_3)_2$
Minus Potassium	NaH_2PO_4 Substituted for KH_2PO_4
Minus Phosphorus	KCl Substituted for KH_2PO_4
Minus Magnesium	Na_2SO_4 Substituted for $MgSO_4$
Minus Sulphur	$MgCl_2$ Substituted for $MgSO_4$
Minus Boron	H_3BO_3 Omitted
Minus Iron	Ferric Citrate Omitted

and Phlox showed definite symptoms five days after calcium was withheld and Salvia a few days later. The plants were stunted and pale and made no additional growth after the symptoms became evident. The top portions of the plants were affected first. The upper leaves became grayish-yellow in color and the veins turned brown. Later the veins and portions of the stems at the leaf axes became dark brown and black, and the growing tips died. Finally the entire plant including the lower leaves turned grayish-yellow and unless small amounts of calcium were added the plants died very soon. None of the minus calcium plants produced flowers unless calcium was finally added. The roots of the minus calcium plants were very dark brown in color and poorly developed.

Potassium Deficiency.—The potassium deficiency symptoms appeared about ten to twelve days after potassium was withheld. The plants were stunted and pale. The lower leaves of Petunia were wilted and some had cream colored spots which became dry giving the leaves a mottled appearance. Later all the leaves became very chlorotic and wilted. The dry leaves were light brown in color. The leaves of Salvia did not become extremely chlorotic but they were wrinkled and curled and severely scorched. The lower leaves were affected first and finally most of them fell off. The dry leaves of Salvia were also light brown in color. The leaves of Phlox were rather chlorotic and the tips of particularly the lower leaves were yellow and brown.

Phosphorus Deficiency.—All the phosphorus deficient plants were spindling, stiff, and had a very characteristic dull bluish-green color. As the deficiency symptoms progressed the leaves turned to a dull yellowish-green color. In Petunia only the first or second lower leaves became dry and fell, but in Salvia all the leaves were burned at the tips and all the lower leaves up to the fourth or fifth nodes from the bottom had dried and fallen off. The leaves were not wrinkled as they were in potassium deficient plants. The dry leaves of both Petunia and Salvia deficient in phosphorus were very dark brown in color.

Magnesium Deficiency. — Magnesium deficiency symptoms were evident within ten days after magnesium was withheld. At first the plants were only slightly stunted but the leaves were very chlorotic. The leaf discolorations varied from pale green to almost white. The veins and the areas just next to the veins usually retained a light green color. The Petunias were the most chlorotic of the magnesium deficient plants. The leaves of Salvia became dry rather than extremely chlorotic and finally all but the very uppermost leaves dropped.

Sulphur Deficiency.—The sulphur deficiency symptoms, although apparent, were not as pronounced as the others described. The sulphur deficient plants were less vigorous and bushy than the control plants and were lighter in color. The leaves were pale in general but no pronounced chlorosis or drying took place. In Petunia the lower leaves were

TABLE 2.—PETUNIA

	Average for one plant, Grams				% Dry weight entire plant	% Dry weight tops	% Dry weight roots	Wet top-root ratio	Dry top-root ratio
	Wet top weight	Wet root weight	Dry top weight	Dry root weight					
C	233.00	3.54	21.56	0.53	9.33	9.25	14.97	65.81	40.67
—N	0.47	0.23	0.12	0.06	25.71	25.53	26.08	2.04	2.00
—Ca	.....	.....	0.61	0.12	.....	.....	.....	.....	5.08
—K	3.15	0.39	0.71	0.06	21.75	22.54	15.38	8.07	11.83
—P	2.77	0.58	0.50	0.10	17.91	18.01	17.24	4.77	5.00
—Mg	.....	.....	0.38	0.07	.....	.....	.....	.....	5.43
—S	124.00	17.75	10.63	3.05	9.65	8.57	17.18	6.98	3.48
—B	4.60	0.57	0.44	0.07	9.86	9.56	12.28	8.07	6.28
—Fe	232.00	7.98	22.83	1.31	10.05	9.83	16.41	29.07	17.42

Table 3.—Salvia

	Average for one plant, Grams				% Dry weight entire plant	% Dry weight tops	% Dry weight roots	Wet top-root ratio	Dry top-root ratio
	Wet top weight	Wet root weight	Dry top weight	Dry root weight					
C	176.00	61.00	28.81	6.47	14.04	15.23	10.60	2.88	4.14
—N	0.64	0.39	0.06	0.07	12.62	9.37	17.94	1.64	0.85
—Ca	6.79	4.95	1.07	0.60	14.22	15.75	12.12	1.37	1.78
—K	3.08	2.75	0.31	0.26	9.77	10.06	9.45	1.12	1.19
—P	1.02	1.90	0.17	0.16	11.30	16.66	8.42	0.53	1.06
—Mg	0.78	1.17	0.12	0.14	13.33	15.38	11.96	0.66	0.85
—S	67.00	30.00	9.47	2.66	12.50	14.13	8.86	2.25	3.56
—B	21.80	8.35	3.06	0.97	13.36	14.03	11.61	2.61	3.15
—Fe	105.00	47.00	6.94	5.60	8.25	6.60	11.91	2.23	1.23

affected more than the upper ones. Several flowers were produced by all plants. The total dry weight of the top portion of the sulphur deficient Petunia plants was about half that of the control plants, but the total root weight was almost six times greater than that of the control plants. The root weight of the sulphur deficient Salvia plants was less than half that of the control plants.

Boron Deficiency. — The symptoms caused by boron deficiency were very striking in all the plants. They were evident from eight to ten days after boron was withheld. Petunia and Phlox grew only 3 to 8 cm. in height, and produced no flower buds. In a very short time the central leaves and the growing tip became yellowish-brown to bronze in color and terminal growth stopped. Several lateral buds appeared, but before long they were similarly affected and also stopped growing. This resulted in a short greatly fasciated plant. Several boron deficient Petunia and Phlox plants died before the experiment was finished.

Fig. 1.—Photograph showing mineral deficiences in phlox series.

The leaves of the Petunia plants were small but thick and very brittle. They were very deformed often being curled, rolled, and stubby, and had an oily or greasy appearance. The leaves of Phlox and Salvia did not have this oily appearance. The Salvia plants had small discolored leaves but did not develop the fasciated condition as was found in Petunia and Phlox. The growing tips in all Salvia plants died, but the lateral shoots usually made considerable growth before they stopped growing. Several flower buds were produced by these lateral shoots, but the flowers were very small and poorly developed. The roots of both Petunia and Salvia were very poorly developed, coarse, and dark in color. The extremities of the roots were blunt or bulbous rather than fibrous.

Iron Deficiency.—Petunia and Salvia showed only very slight iron deficiency symptoms. Petunia was not affected in growth or general vigorousness but had a few chlorotic leaves. Salvia made less total growth when deficient in iron but the plants were not chlorotic. The sand used in these experiments contained impurities of iron which apparently was available to the plants. The iron deficient Phlox plants were grown in sand from which the iron had been removed by several treatments with hydrochloric and nitric acid. The acid treated sand was carefully leached with distilled water to remove all traces of soluble iron and acid. Phlox grown in this iron free sand were stunted and very chlorotic. The chlorotic leaves were in some cases mottled and in others very light in general. The newer leaves were particularly light. The veins of even the more chlorotic leaves usually retained their green color. No drying or leaf destruction took place in these plants.

Fresh and dry weights of the top- and root-portions of Petunia and Salvia were taken at the time of harvest. These with other data are shown in tables 2 and 3. A photograph of the Phlox series is shown in fig. 1.

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THE USE OF FLUORESCENT LIGHT IN EXPERIMENTAL WORK

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Light is one of the most important environmental factors. One of the most difficult problems confronting the plant physiologist in his effort to control the environment has been the finding of a suitable artificial light source. Obviously the ideal light source for physiological work depends entirely upon the type of experiment being performed. If light, however, is not a variable the best type of light would be one approaching daylight in both visible and invisible radiations. Therefore, the most important criterion which might be used in selecting an efficient light source is concerned with the nature of the spectral distribution. Of primary importance also is the determination of whether the spectral distribution follows the photosynthetic curve. In addition it should be remembered, that radiations other than those efficiently involved in photosynthesis may exert considerable effect upon the formation of hormones and other substances which influence the general growth form of the plant.

There have been many objections to the light sources used in the past; some of these were on the basis of quality or intensity or both, and others were on the basis of cost of installation and maintenance of equipment. Until recently the best source of artificial light from the standpoint of quality was carbon-arc light. Light from this source approximates that of sunlight except that its radiations are higher in ultra-violet and the blue. Other than that it is of excellent quality. One of the more important objections to its use, however, is that the units are heavy and relatively non-portable; thereby practically forcing one to use them in the rooms where they are installed. Also such units are both costly to install and to maintain.

Comparatively recently lamps emitting fluorescent light have become available. Some experimentation has been done with arrangement, spacing, color and wattage of tubes, and with various reflecting surfaces in order to ascertain the usefulness of fluorescent light in various types of experimental work. As a further test the lamps have been used as the sole source of illumination in light tight compartments and supplemental to the normal daylight period.

Good results have been obtained from reflectors built to hold six 36-inch tubes, the reflecting surface being painted with a water soluble white casein paint (fig. 1A). These reflectors have been used successfully as a source of supplementary illumination when suspended over the greenhouse benches, where during the day they can be raised by means of pul-

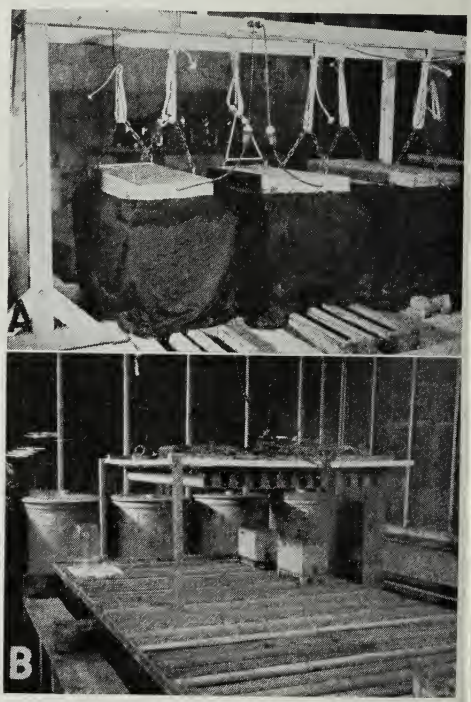

Plate I.—A. Reflectors arranged on scaffolding in light-tight basement with double thickness black sateen cloth curtains around flanges to exclude light from adjacent sources. B. Flat type reflector mounted over a greenhouse bench for use as a supplementary light source. One side can be tilted to prevent shading during the day either by using a chain suspended from the ceiling or by props.

leys to such a height that their shadows will not be cast over the plants. Such a suspension system may also be conveniently used to adjust intensities to the desired level. Best results, however, have been obtained with flat reflecting surfaces to which were attached twelve 48-inch tubes spaced 1½ inches apart at the center of the electrodes. The suspension system has been satisfactorily used with this type of reflector; and another way in which it may be used to advantage is to provide it with legs which may be readily replaced as the plants grow (fig. 1B). Such a reflector may be used for supplementary illumination during the night. During the daylight hours it may be tilted at such an angle that shadows are not produced either on the bench which it covers or the adjacent one.

In terms of foot-candles of light obtainable, it is found, within limits, that the higher the wattage and the closer the tubes are spaced the higher the obtainable intensity. Because of the difference in surface illumination of the different colored tubes the height at which a given intensity may be obtained by a given bank of lights is variable. The highest intensity obtained with the 36-inch (30-watt) white fluorescent tubes has been 1200 foot-candles; while a bank of twelve 48-inch (40-watt) tubes will give 2000 foot-candles at a distance of from 4-5 inches below their surface. But a similar number of daylight type tubes of the same wattage give lower intensity readings.

The quality of light obtainable from fluorescent tubes varies with the kind of phosphore which is used to coat the inner surface of the tube. Inasmuch as these phosphores may be mixed, a variety of colors can be obtained. The spectral distribution curves for the different colored tubes, when compared with the photosynthetic curve given by Hoover(1) indicate that the daylight type would be the most efficient because the two maxima for both curves occur in the same regions. It should be noted, however, that the highest maximum reached in the two curves is exactly reversed, the highest peak being in the red end of the photosynthetic curve while the highest energy level obtained from the fluorescent tube is in the blue region. Distribution curves for all the other tubes, with the exception of the white tube seemingly indicate that they would be comparatively inefficient in plant growth.

When used as the sole source of illumination both the white and daylight tubes have proved to be exceptionally efficient in the growth of a number of plants. Those most successfully grown under them include cabbage, corn, a variety of annual beet, red kidney bean, Biloxi, soybean, dill, tobacco and tomato (2, 3). All of these have been grown in soil, while tomato and bean have also been grown in sand culture. Those plants tried—dill, annual beet, red kidney bean, and tomato—have flowered as rapidly or almost as rapidly when the intensity was sufficiently high as those grown under the best greenhouse conditions at Chicago.

Tubes of the 30-watt type emitting gold, green, and blue light have been used for growing beans and tomatoes. Although these lamps are far from supplying monochromatic light their radiations are confined to certain regions of the spectrum and because they do cover a fairly large spectral range can be successfully used in a variety of preliminary experiments designed to determine the effects on growth of variables such as mineral nutrition and temperature within certain portions of the spectrum. More refined techniques can then be used to determine effects produced by spectral lines within any given band.

An illustration of this point may be found in one of the bean experiments. Two series of beans were given similar environmental conditions under different reflectors supplying gold, green, blue, daylight, white, and a mixture of all these plus red. Half the plants received ammonium sulphate as a source of nitrogen while the other was supplied with calcium nitrate. Those plants supplied with nitrate as a source of nitrogen have invariably grown more vigorously than those supplied with ammonium. Yet with ammonium there were distinctive differences in the growth rate depending upon the color of light used. The plants which first showed adverse effects of ammonium were those grown under blue light while retardation in growth appeared last in those grown under gold light. Within the nitrate series there have also been striking differences. One outstanding difference

which might not be expected on the basis of the efficiency curve for photosynthesis was that the size of leaves and height of plants growing under the blue lamps was much greater than under the gold lamps. This obviously indicates that factors of a photochemical nature other than photosynthesis are involved.

An effect which was noted in both series was that under gold light leaves of bean assumed the position of "sleep movement," while normal leaf position was evident under all the others. Blue light seemingly induces the leaves to stand out more rigidly. This same response has also been noted in *Oxalis violacea*. Evidently then light quality as well as intensity is related to sleep movement. More exact experiments could be designed to determine the effects of narrow bands of yellow, orange, and red.

In conclusion it may be said that with the aid of fluorescent lamps it is possible to control satisfactorily the quality and quantity of light in experimental work, whether the lamps are used as the sole source of illumination or for supplementary illumination.

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TRACE ELEMENTS IN OATS AND SUDAN GRASS

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There has been a considerable interest in the last several years among agronomists and plant physiologists as to the role of the trace elements in plant metabolism. These elements have been called by various workers "rare", "secondary", or "minor" elements. Such terms are used because the elements in question are found in small amounts in the plant tissue and appear to be necessary to the plant in very low concentrations. As an indication of the interest in this phase of physiological research, Willis in 1935 published a bibliography of 1805 abstracts and references to the trace elements. In 1937 a second edition appeared containing 2766 abstracts and a third edition appeared in 1939 containing 4628 references. Since 1939 several thousand additional papers have been published.

Between 1860 and 1890 such plant physiologists as Sachs, Knop, Nobbe and Pfeffer had developed the almost classical precept that carbon, oxygen, hydrogen, nitrogen, phosphorus, potassium, calcium, magnesium, sulphur and iron were the only elements essential for the existence of the green plant. With the development of chemical methods of analysis it became apparent that the experimental methods of the early workers did not justify the exclusion of other chemical elements from the list of essential elements.

Mazé between 1914-1919 and more recently others have shown that normal plant metabolism requires a number of other elements. Careful research with especially purified reagents has suggested that boron, manganese, zinc, and copper are essential for green plants. McHargue considered that plants obtain such factors as are necessary for their growth from the soil, taking up small amounts of iron, manganese, copper, zinc, boron, nickel and others. With the aid of these elements the plant synthesizes complex organic compounds. He further considered that these organic compounds function as enzymes, catalysts and vitamins and that when they are consumed by animals they are resynthesized into catalase, oxidase, hormones, and animal vitamins.

During the course of some vitamin research on cereal grass a number of samples of oats and Sudan grass were received from the vicinity of Brownsville, Texas. One of these grass samples was definitely green in color and another definitely yellow while a third appeared to be somewhat intermediate in color. It was decided to run a series of analyses on the grass tissue to determine whether the cause of the chlorosis was due to a nutritional difficulty. From the outward appearance of the plants it could not be determined whether the chlorotic condi-

tion was due to a lack of certain elements or whether due to excess amounts of certain elements resulting in a toxicity condition. There are numerous colored photographs in the literature to show that chlorosis can result from either a deficiency or toxicity of chemical elements. Because of the small amount of tissue available for study spectrographic methods of analyses were utilized* The grass was ashed and concentrated and a 5 mgm. sample used in the determination. The spectrum of the grass was recorded on a photographic plate for study.

The absolute amounts of the different elements present were not determined. The first determination consisted simply of photographing the arc-produced spectrum of the grass sample and then identifying the principal lines present. This gave an idea of the elements present. A second determination was made by photographing the spectrum of the three samples on the same plate. By the use of a densitometer it was possible to obtain some idea of the relative amounts of the various elements present in the three samples studied.

In addition to the major elements calcium, magnesium, potassium, sodium, and phosphorus, the trace elements manganese, copper, iron, aluminum, boron, and silicon were identified. Zinc was not found on all of the plates and it was not certain whether it was present at all. Many workers believe that zinc, like copper, will prove to be an essential element for the higher plants.

In this preliminary study no attempt was made to determine quantitatively the amounts of the elements present. The purpose of the study was to find whether or not any of the trace elements were absent, or whether any elements were present in excessive amounts. An evaluation of the relative amounts present was attempted by comparing densitometer readings of the various elements. These relative amounts are shown in the accompanying table:

Sample	*Ca*	*Mg*	*K*	*P*	*Fe*	*Na*	*Mn*	*Cu*	*B*	*Si*	*Al*	*Zn*
Definitely green	x	x	x	x	1	x	1	1	x	x	x	x
Intermediate	x	x	x	x	3	x	3	3	x	x	x	x?
Definitely chlorotic	x	x	x	x	2	x	2	2	x	x	x	?

x—element present
1—highest amount of element as shown by densitometer values
2—intermediate amount of element
3—lowest amount of elements as shown by densitometer values

The comparison of densitometer readings showed that there was a gradation in the relative amounts of iron, manganese and copper present in the samples. One of the interesting features of this preliminary study was the fact that the grass sample intermediate in color between the normal and chlorotic samples was not intermediate in mineral content as determined by comparing the line density values with a densitometer. In most cases the relative amounts of the trace elements in this intermediate sample were less than those amounts indicated to be present in the chlorotic sample.

The results do not indicate whether the yellowing of the grass leaves was due to a deficiency of some essential element or due to a toxicity reaction caused by excessive amounts of some element being present. Soil studies made did not offer much help in explaining the chlorosis. It is known that the soil in the vicinity where the grass was sampled is decidedly alkaline in reaction. This suggests the possibility of iron being immobilized by the alkaline soil reaction and thus becoming unavailable to the plant.

* I am indebted to K. R. Majors, formerly of the U. S. Soybean Lab. for his advice and assistance on the spectrographic work.

SOME QUANTITATIVE ASPECTS OF PHOTOTROPISM

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The Bunsen-Roscoe law, which states that a given magnitude of stimulus always calls forth the same response, regardless of its distribution in time, and the Weber-Fechner law, which states that the increase in intensity of stimulus necessary to produce an appreciable response is always a constant fraction of the intensity of stimulus to which a sensitive organ is already exposed, have been shown to apply to the responses of certain species of plants. Investigations upon the applicability of these laws to plant reactions have been infrequent, however, and the present work was undertaken to determine whether or not these laws hold in the phototropic responses of seedlings of corn (Reid's Yellow Dent), perennial rye grass (*Lolium perenne* L.). Alaska peas, radish (Scarlet Globe), and sunflower.

The experiments were carried out in a constant-temperature room completely darkened, except for a spectrally-tested, phototropically-inactive, red lamp, which was turned on only during readings. The light stimulus was obtained by the use of standard 7½ watt, 60 watt, and 100 watt frosted-glass electric lamps. A series of intensities was obtained by exposing the experimental plants at varying distances from the light source. All intensities were determined at the plants by a Macbeth Illuminometer.

A. Bunsen-Roscoe Law.—In the experiments involving this law, the plants were exposed to light sources of varying intensity and the average phototropic presentation time was determined for each intensity by observations upon 10 to 18 plants. The light intensity in foot-candles was then multiplied by the phototropic presentation time for the seedlings exposed to that intensity. If the Bunsen-Roscoe law is valid for phototropic responses, then the values of the various intensities used, multiplied by their respective presentation times, should be approximately constant. The results of typical experiments are presented in table I.

B. Weber-Fechner Law.—In these experiments, the experimental set-up pictured in fig. 1 was used. The box, which was 10 feet long by 1 foot high by 1 foot wide was left open on one side and at the ends, and was painted black. The plane mirrors employed were 4 by 6 inches and were supported opposite the open ends of the box, as indicated. The source of light was placed approximately 2 feet above the center of the box and the seedlings, grown in darkness, were placed at measured points as indicated in the figure—one pot at the midpoint (0) of the box, then a series to the left of the midpoint at 3 inches, 9 inches, 15 inches, and 21 inches respectively from the midpoint. In each experiment, the plants were exposed for three hours to the light reflected to them by the mirrors. By varying the distance of the mirrors from the light source and point 0 it was possible to obtain different light inten-

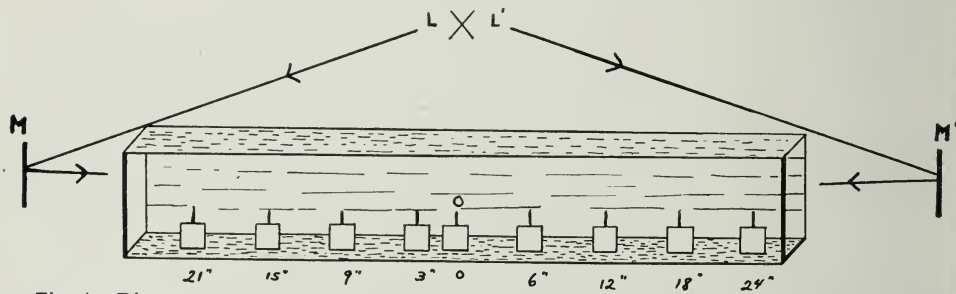

Fig. 1.—Diagram of box used in experiments. L=light source. M,M' = mirrors. O=midpoint between mirrors.

TABLE I

Intensities	Peas		Corn		Radish		Rye Grass		Sunflower	
	PT	I x PT	PT	I x PT	PT	I x PT	PT	I x PT	I	I x PT
2.70 FC	½	1.35	1/25	.108	1	2.70	1/5	.540	1½	4.05
.635	1	.635	1/5	.123	3	1.91	1	.635	6	3.81
.203	2½	.508	½	.107	10	2.03	2	.406	15	3.03
.166	3	.498	1	.166	11	1.72	3	.498	22	2.65
.056	10	.560	3	.168	40	2.24	8	.448	52	2.91
.039	12	.468	4	.156	50	1.95	10	.390	59	3.30
.014	35	.490	10	.140	150	2.10	40	.560	189	2.64
.0035	140	.490	36	.126	600	2.10	140	.490	895	2.98
		Av. .502FCS		Av. .137FCS		Av. 2.18FCS		Av. .499FCS		Av. 3.78FCS

I=intensity in foot-candles
PT=presentation time (in seconds)
I x PT=product of intensity and presentation time
FCS=foot-candle-seconds

TABLE II. (100 WATT LAMP).—CORN

a feet	*b* inches								*i'*
	3	6	9	12	15	18	21	24	
26				x	x	x	x	x	1.166
19.5			x	x	x	x	x	x	1.166
13		x	x	x	x	x	x	x	1.166

Intensity at O when LM + MO is 13 feet = .254 FC

TABLE III. (60 WATT LAMP).—CORN

a feet	*b* inches								*i'*
	3	6	9	12	15	18	21	24	
26								x	1.361
19.5						x	x	x	1.361
13				x	x	x	x	x	1.361

Intensity at O when LM + MO is 13 feet = .142 FC

sities on the plants; the distances used (from light source to mirror to midpoint) were 13, 19.5, and 26 feet. The sources of light were standard, frosted 60-watt and 100-watt light electric lamps. Intensity measurements were made with the Macbeth Illuminometer.

In each of the experiments, the seedling closest to the midpoint 0 showing the slightest phototropic bending was determined, and calculations were made according to the law of inverse squares. Since the intensity of light is inversely proportional to the square of the distance, it is easy to calculate how much more one side of a seedling must be illuminated than the other in order to produce a phototropic bending. Calculations were made according to the formula

$$\frac{i'}{i} = \frac{(a+b)^2}{(a-b)^2}$$

where a is the distance LM+MO (and also $L^1M^1+M^1O$), b is the distance from 0 to the first curved seedling from the midpoint i^1 is the intensity of the light to the left, and i is the intensity of light to the right. If i is arbitrarily designated as I, then

$$i' = \frac{(a+b)^2}{(a-b)^2}$$

Tables II and III indicate the results obtained from experiments on corn seed-

TABLE IV. (100 WATT LAMP).—RYE GRASS

a feet	*b* inches								*i'*
	3	6	9	12	15	18	21	24	
26					x	x	x	x	1.21
19.5				x	x	x	x	x	1.22
13			x	x	x	x	x	x	1.25

Intensity same as in Table II

lings with coleoptiles approximately 3½-4 cm. tall. In the tables *x* indicates a definite curvature, absence of an *x* indicates no curvature. In a similar experiment upon rye grass seedlings, the results presented in table IV were obtained.

The constancy of *i'* within these experiments indicates that the Weber-Fechner law is applicable, at least roughly within the limits of the light intensities used, to phototropic curvatures in coleoptiles of corn and perennial rye grass seedlings. Within the limits of each experiment, a definite fairly constant proportionality between the light intensities received on opposite sides of the seedlings must obtain before the seedlings is able to curve in the direction of the more intense light.

C. Summary. — 1. The phototropic curvatures of young stems of peas, sunflower, and radish, and of coleoptiles of corn and perennial rye grass, show approximate correspondence with the Bunsen-Roscoe law, within the limits of the experiments.

2. The phototropic curvatures of coleoptiles of corn and of perennial rye grass show approximate correspondence with the Weber-Fechner law, within the limits of the experiments.

The authors express their appreciation to the Graduate Research Board of the University of Illinois for use of the Macbeth Illuminometer.

THE TISSUE CULTURE TECHNIQUE AS A MEANS OF STUDYING CORRELATION

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For many years the tissue culture technique has been utilized as a means of studying the growth requirements of isolated parts of the plant body, especially those of roots (1, 2). In recent years its scope has been extended by many workers to study the role which vitamins and hormones, and related substances, may play in root growth. We have been interested more especially in adapting the technique to the observation of the effects which different organs of the plant exert upon one another during the growth of the plant. The technique involves growing excised parts of the plant body together in the same flask and also in separate flasks. This permits the observation of any effects which may be due to the cutting of the living tissue, and the separation of the excised parts from one another, which may be complete, as when they are isolated, or incomplete, as when they remain in the same flask and the diffusion of substances from one part to the other may still occur.

The plant most extensively studied has been lettuce, of the Grand Rapids tip-burn resistant variety. The seeds are sterilized and then germinated on water-soaked filter paper in previously autoclaved Petri dishes. When the seedlings are two days old, the parts are excised and transferred to the culture flasks. The medium is usually a modification of White's formula. The most widely studied group of cultures contained four series, (1) excised roots alone, (2) excised shoots alone, (3) excised roots and shoots in the same flask, and (4) the whole seedling. By the shoot is meant the entire young stem, including the cotyledons and part of the hypocotyl. Figure 1 is the histogram which results when

the total root growth on each of the parts of this series is compared. It shows clearly that while attached intact to the seedling, the root and its branches receive growth promoting materials from the shoot which are not available to it immediately from the medium, but that the root when present on the seedling greatly inhibits the growth of lateral and adventitious roots.

This same grouping of cultures has been used to study many growth-regulating substances, and when the root growths are diagrammed in the same way as are those in Figure 1, the fact is evident immediately that the different series of cultures differ widely in their response to the same substance. Thus, an over all increase or decrease in the magnitude of this type-figure does not take place, but rather a change in the shape occurs. The conclusion from this is obvious: that deductions which may be drawn from observations of the activity of any substance on excised roots alone must be seriously limited in their scope.

Other plants which we have cultured in this way are peas, canteloupe, and grass. The heterogeneity of response which peas show makes it difficult to use the technique to advantage. The importance of aeration in the development of some plants is shown by the canteloupe. The young stems, when cultured as described above for lettuce, elongate and the cotyledons grow to considerable size, but no differentiation takes place. The shoots and adventitious roots do not develop, but when a mat of glass wool is placed in the flask to support the young stem in the medium, growth is normal and very rapid. This suggests the results of White (3) with callus tissue. That the problem

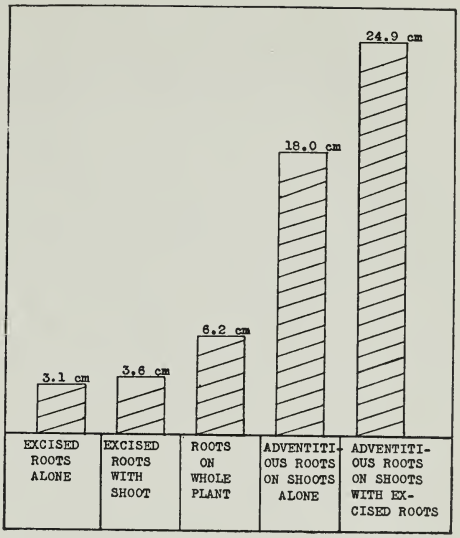

Fig 1.—Total root growth in correlation groups.

is at least partly one of aeration is further substantiated by the fact than when only a small portion of the stem is supported above the liquid surface, numerous adventitious roots make their appearance on that portion. On the other hand, young grass plants develop as well when submerged in the liquid medium as when on agar, and moreover, this growth compares favorably over periods of three or four weeks with that taking place in sand culture.

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AN EVALUATION OF GENERAL METHODS OF "DEOXYGENATION" OF WATER

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The recent interest in the physiology of aquatic plants and animals has stimulated the application of a technique employing "oxygen deficient" water (Kostychev and Soldatenkow, 1926; Gessner, 1938). One phase which has not received adequate attention is the methods of preparation of this medium.

Three mechanical methods for reduction of the gaseous content of water are in general use: (1) heating, (2) displacement by another gas, and (3) application of partial vacuum. Perhaps to date heating has been the most popular, but is found to disturb chemical and organic factors of natural water. Data are given which indicate the effectiveness of each method.

Heating.—One liter quantities of distilled water were heated in a 2 liter Erlenmeyer flask over a Fisher burner which increased the temperature of the water at the rate of about 7°C. per minute. Samples were siphoned off before and after treatment of each quantity into 200ml. flasks. Determinations of dissolved oxygen content were made by the Winkler method. Data are given in table I.

Nitrogen Substitution.—One liter quantities of distilled water were placed in a one liter Buchner flask, and nitrogen was bubbled through the water from the bottom. The rate of 0.1 cubic feet per minute was chosen, because preliminary tests indicated that at this rate nearly maximum deoxygenation seemed to be affected per unit time. Samples of water were drawn, and the dissolved oxygen concentration determined as outlined above.

Partial Vacuum.—One liter quantities of distilled water were added to a 1 liter Buchner filtering flask which was attached to a mercury manometer by one lateral tube and to an aspirator by a second. Maximum water flow through the pump was used in all experiments, and reduced the air pressure in the flask from 756.1 mm. Hg. to 16.1 mm. Hg. Samples of water were drawn and the dissolved oxygen concentration determined as outlined above.

TABLE I.—DEOXYGENATION OF WATER WITH HEAT

Length of treatment min.	Temperature °C.	Oxygen concentration mg./L.	Percent of original oxygen concentration
0	29.0	6.8	100.0
2	38.5	6.8	100.0
4	55.0	6.0	88.2
6	75.0	5.4	79.4
8	91.0	3.8	55.8
10	100.0	0.8	11.8

TABLE II.—DEOXYGENATION OF WATER WITH NITROGEN GAS BUBBLED THROUGH AT THE RATE OF 0.1 CUBIC FEET PER MINUTE

Length of treatment min.	Total nitrogen bubbled through cu. ft.	Oxygen concentration mg./L.	Percent of original oxygen concentration
0	0.0	9.2	100.0
1	0.1	7.4	80.5
2	0.2	5.0	54.5
4	0.4	2.8	30.5
6	0.6	1.7	18.6
8	0.8	1.2	13.1
10	1.0	0.9	9.3

TABLE III.—DEOXYGENATION OF WATER UNDER REDUCED PRESSURE (16.1 mm. Hg.)

Length of treatment min.	Oxygen concentration mg./L.	Percent of original oxygen concentration
0.0	9.8	100.0
5.0	7.8	79.6
10.0	7.6	77.6

TABLE IV.—DEOXYGENATION OF WATER UNDER REDUCED PRESSURE (16.1 mm. Hg.) WITH VIGOROUS SHAKING BY HAND DURING TREATMENT

Length of treatment min.	Oxygen concentration mg./L.	Percent of original oxygen concentration
0.00	9.8	100.0
0.75	1.8	23.7
1.00	1.2	12.2
2.00	0.6	7.9
2.50	0.4	4.1
5.00	0.4	4.1

To accelerate oxygen reduction, the preceding experiment was repeated with the one exception that the flask was shaken vigorously by hand in absence of an automatic oscillator.

The accompanying graph (Fig. 1) summarizes the data above in terms of relative rate of deoxygenation of water per unit time.

Discussion.—The aspiration technique for the deaeration of water has proved of such interest to men in the field of chemistry and zoology at Northwestern University that I have attempted to make these data of a general nature. The apparatus and techniques are not elaborated beyond mere duplication of the procedures in general use, for the purpose was to evaluate the methods as actually employed. Each method, however, has peculiar advantages which should be recognized. By merely heating a given quantity of water to a particular temperature one can approximate a desired oxygen saturation, whereas without an automatic oscillator the aspiration method is difficult to standardize. The nitrogen method, by displacing the oxygen with nitrogen, has the advantage of more closely approximating true *oxygen deficient* rather than *deaerated water.* Aspiration has the advantage of rapidity of action and simplicity of method in accomplishing the same effect as boiling, but without disturbing the physio-chemical factors.

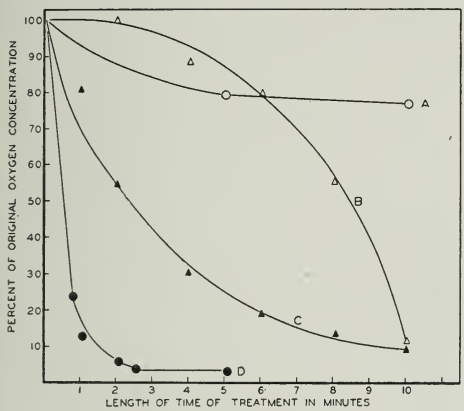

Fig. 1.—Graph of reduction in dissolved oxygen concentration of distilled water by (A) partial vacuum, (B) heating, (C) displacement by nitrogen, and (D) partial vacuum with oscillation.

I am indebted to Dr. B. S. Meyer under whom this work was begun, to Dr. R. O. Freeland for many valuable suggestions, and to Dr. P. Haensel for the excellent facilities of the High Pressure and Catalytic Laboratories at Northwestern University.

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PHYSIOLOGICAL DISTURBANCES IN TOBACCO PLANTS ACCOMPANYING MOSAIC INFECTION

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Seeds of Burley tobacco plants were germinated in the greenhouse and the seedlings transplanted into two-inch pots as soon as they were large enough to handle. As growth proceeded, the plants were repotted successively into four and eight inch pots. When the plants had five well developed leaves, the lower two were removed, and the lowest remaining leaf was designated as number one and the higher leaves numbered consecutively. Several new leaves appeared during the course of the study and they were designated by consecutively higher numbers as soon as they were large enough to be included in the experimental material.

Leaf number one was inoculated with the mosaic virus by rubbing a small area with a piece of cheesecloth soaked with press juice of plants in an advanced stage of the disease.

At intervals of two or three days, the leaves of similar age from normal and inoculated plants were studied in the laboratory to observe changes in respiratory rate, and in the activities of peroxidase, oxygenase, catalase and invertase.

The purpose of making the above observations was to discover if there was a significant difference in the time required for the plant to show a physiological disturbance and that required to attain an infectious concentration of newly formed virus.

The rate of oxygen used by the leaves of mosaic infected plants was greatly increased by the fourth day after the lower leaf was inoculated. This period of stimulated metabolism preceded by approximately ten days the general appearance of the virus in infectious concentrations. The enzymes also showed a disturbed activity very soon after infection. These data show that the appearance of newly formed virus in infectious concentration occurs approximately ten days after the tobacco plant has undergone profound physiological changes. This

TABLE 1.—The Physiological Activities of Leaves From Mosaic Infected Tobacco Plants Expressed as Percentages of the Activities of Leaves of Similar Age From Normal Plants.

Leaf	Oxygen use				Oxygenase				Peroxidase			
	Maximum		Minimum		Maximum		Minimum		Maximum		Minimum	
	Value	Day	Value	Day	Value	Day	Value	Day	Value	Day	Value	Day
Leaf 1	137.0	4	83.7	18	200	14	49	6	143	11	74	4
Leaf 2	119.8	2	82.3	18	250	14	66	4	108	14	95	8
Leaf 3	111.3	4	94.9	6	165	6	81	4	100	14	94	4
Leaf 4					125	11	80	4	120	14	98	4
Leaf 5					200	14	72	8	100	16	87	14
Leaf 6	99.7	18	77.7	21	125	16	100	14	131	16	91	14

Leaf	Catalase				Invertase			
	Maximum		Minimum		Maximum		Minimum	
	Value	Day	Value	Day	Value	Day	Value	Day
Leaf 1	210	11	69	2	273	16	78	6
Leaf 2	315	8	92	2	143	18	72	8
Leaf 3	223	8	86	2	110	11	77	8
Leaf 4	169	18	67	8	106	11	85	6
Leaf 5	354	18	76	6	103	11	74	18
Leaf 6	146	18	47	8	117	11	65	16

indicates that it is not impossible for the virus substance to be a product of this abnormal metabolism. If the observed physiological changes were due to a direct effect of the virus itself, one would expect the disturbances to parallel or follow the appearance of the virus, but actual observations show that the amount of virus present at any time has no relation whatever to the magnitude of the disturbed metabolism of the plant.

A detailed discussion of the data will be published at a later date.

A DEVICE FOR VISUALIZING THE SOLUTION OF GENETICS PROBLEMS

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Last year a paper was presented to the Academy in which the project method developed in the Biology Department at Loyola University was outlined. This year one of these projects will be presented in detail. This particular project involved the building of a device for visualizing the solution of genetics problems.

The construction of this device is simple, as the accompanying diagrams indicate. It consists essentially of a box 15¼"square. (See fig. 1.) This is made of one inch white pine fastened together with screws. The box is 6" deep. It has a solid back of one inch pine, recessed ½". This half inch space contains the wiring. There is a second, removable back of ¼" three-ply wood which conceals the wiring. Attached to the solid back on the front side are sixteen sockets containing sixteen watt bulbs. Partitions of ¼" ply wood separate these bulbs and form square inclosures, the dimensions of which are given in the diagram. This size was chosen because we use a 3¼" x 4¼" camera to make the transparencies.

The open front of these compartments is covered with a piece of ground glass 14¼" square. This slides in grooves cut into the sides of the box as shown. A piece of clear glass 13½" square fits into four brass guides bent into shape to receive it. There is a space of about 3/16" between the two glasses into which the transparencies about to be described fit.

A smaller box is hinged to the top of the larger one. Dimensions of this are given in fig. 1. It contains the sixteen switches used to control each individual light. The wiring is somewhat tedious,

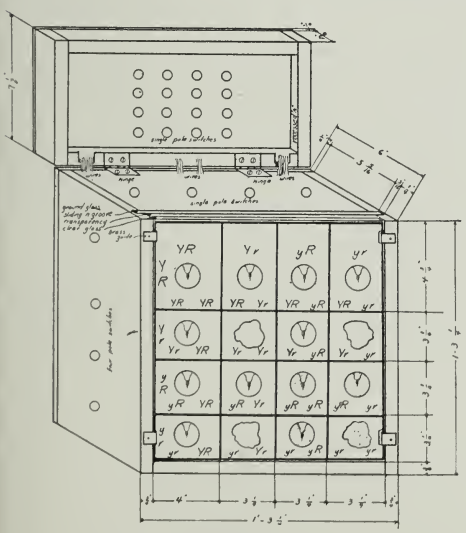

Fig. 1.

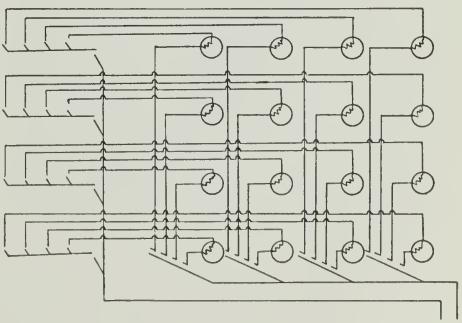

Fig 2.

but not very complicated. As the diagram (fig. 2) shows, four switches across the top of the box control one side of the lamps in groups of four. When these switches are closed, the sixteen switches in the upper box each control one side of a single lamp. The four switches on the left side of the box are four pole switches. Considerable difficulty was experienced in obtaining this type of switch, so they were constructed in the laboratory. They consist of a brass cylinder attached to a wooden knob. This cylinder slides in and out of a hole in the box. A wire from the line is soldered to the cylinder. Brass strips are soldered to each of four wires coming from a row of four lights. These strips are bent and screwed into place so that the cylinder, when pushed in, makes contact with all four at once. This type of switch is necessary to prevent current feeding back through the lamps, thus throwing several into series.

The transparencies are made of two pieces of x-ray film from which the emulsion has been removed by soaking in a dilute warm solution of sodium hydroxide. Such films may be obtained gratis from any hospital. They are cut into 13½" squares. On one, letters representing genes are printed as indicated in the example. We found that India ink has a tendency to crack off, so the type of opaque used by photographers in retouching was used. Appropriate drawings are made with India ink and copied on process film. From the negatives the desired number of positives are made on process film. These are colored with Eastman water colors. They are then lined up on the x-ray film and held in place by small bits of scotch tape. Finally, eight strips of scotch tape (the opaque type used to bind lantern slides) are arranged as shown in the diagram. The squares so formed correspond to those formed inside the box by the plywood partitions. The second x-ray film is placed over the positives, and the whole bound together with scotch tape.

A door covers the open front of the box. This was not shown in the drawing, in order to save space. It is hinged on the right, and fastens to the left side with a snap catch. The top also folds down and fastens to the door by another snap catch. A handle attached to the top permits easy carrying. The electric cord for power supply comes in near the bottom on the right side.

This project as such was very successful. It required the combining of information of very diverse kinds. A knowledge of genetics, physics, photography, and some practical carpentry were required. Not only were those actively working on it interested, but many others displayed a keen interest.

Besides the routine solution of problems, it is possible to demonstrate various other points. For instance, students often are unable to understand why a double recessive is used in test crossing. If a transparency is put into place, and the four egg switches closed, it is possible to demonstrate the utility of the recessive. If the switch controlling the sperm carrying both recessives is closed, four phenotypes appear. If any egg switch is opened, the ratios are changed, proving that only one possible female can give such results. If any other sperm switch is closed, then two, or even three egg switches may be opened without changing the ratio. This demonstrates that only the double recessive will reveal an unknown genotype. We have not had an opportunity to use the machine sufficiently to determine its usefulness. It is hoped, however, that it will arouse the curiosity of the students and thus lead them to an interest in a subject which is ordinarily considered abstruse. It is planned to demonstrate in lecture, and then allow the students to work out problems during laboratory periods or at other times.

One of the projects for several years to come will be the addition of various transparencies to those we already have.

A COLLECTION OF MYXOMYCETES FROM EASTERN ILLINOIS

E. L. Stover

Eastern Illinois State Teachers College, Charleston, Illinois

This collection of the saprophytic Myxomycetes was started by a student, the late Miss Helen Ruck. It has been added to by the writer, Mr. H. F. Thut and students. This collection is maintained as a unit for use in a course of study of the non-green plants. It is presented to the botany section of the Academy as an interesting and useful collection demonstrating this group of plants and as a group useful in teaching the use of keys for the identification of plants. The collection contains nineteen or twenty genera and from forty to fifty species. The following list is a record of these species collected in Coles and Clark Counties in Illinois. Specimens are available to anyone who wants to examine them in the botany laboratories of the Eastern Illinois State Teachers College.

The identifications were made from the keys in the book by Macbride and Martin, *The Myxomycetes*. A part of the identifications have been checked by Professor Martin.

Ceratiomyxa fruticulosa *(Muell.) Macbr.*
Fuligo septica *(L.) Weber*
Badhamia Versicolor *Lister*
Badhamia foliicola *Lister*
Physarum compressum *Alb. and Schw.*
Physarum notabile *Macbr.*
Physarum polycephalum *Schw.*
Physarum viride *(Bull.) Pers.*
Physarum spp.
Diderma crustaceum *Peck.*
Diachea leucopodia *(Bull.) Rost.*
Stemonitis fusca *Roth.*
Stemonitis virginiensis *Rex.*
Stemonitis fenestrata *Macbr.*
Stemonitis splendens *Rost.*
Stemonitis axifera *(Bull.) Macbr.*
Comatricha longa *Peck*
Comatricha irregularis *Rex*
Comatricha typhoides *(Bull.) Rost.*
Comatricha pulchella *(Bab.) Rost*
Comatricha sp.
Lamproderma arcyrionema *Rost.*
Cribaria dictydiodes *Cook and Balf.*
Dictydium cancellatum *(Batsch) Macbr.*
Licea tenera *John*
Licea fimicola *Dearness and Bisby.*
Tubifera casparyi *(Rost) Macbr.*
Tubifera ferruginosa *(Batsch) Gmel.*
Reticularia lycoperdon *Bull.*
Lycogola epidendrum *(L) Fr.*
Perichaena quadrata *Macbride*
Arcyria cinerea *(Bull) Pers.*
Arcyria digitata *(Schw.) Rost.*
Arcyria denudata *(L) Wettstein*
Oligonema nitens *(Lib.) Rost.*
Hemitrichia serpula *(Schop.) Rost.*
Hemitrichia stipata *(Schw.) Macbr.*
Hemitrichia vesparium *(Batsch) Macbr.*
Hemitrichia clavata *(Pers.) Rost.*

BRYOPHYTES OF ROCKY BRANCH REGION OF CLARK COUNTY, ILLINOIS

R. Harold Vaughan

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In the northern part of Clark County there is a small creek called Rocky Branch which joins Big Creek about two miles northeast of the village of Dolson (Clarksville). This stream runs for almost a mile in its lower course through a gorge cut in sandstone. Botanists and zoologists of east central Illinois have long known Rocky Branch to be an interesting place. The author believes, however, that no one has ever made extensive collections of Bryophytes there.

The area explored for this study includes Rocky Branch gorge, some ravines which enter the gorge, and the rocky cliffs on Big Creek near the junction of the two streams. All together the region includes less than one square mile of land. Woods, streams, and moist rocky banks and cliffs furnish a wide variety of habitats where Bryophytes flourish. Collections were made during the late summer and autumn of 1940 and the spring of 1941. Time did not permit a thorough exploration of all the promising parts of this region and it is quite probable that several other species of Bryophytes may be collected there later.

Duplicate samples of this collection have been sent to Dr. Stella M. Hague for the Illinois Collection at the University of Illinois and to Dr. W. C. Steere for the Herbarium of the University of Michigan. Samples of the Hepaticae have been sent to Dr. Margaret Fulford for the Hepatic Herbarium of the Sullivant Moss Society at the University of Cincinnati. The author is greatly indebted to Dr. Steere, Dr. Hague, Dr. Fulford and Dr. A. J. Grout for the assistance given in the identification of the Bryophytes collected.

HEPATICAE

Calypogeiaceae

Calypogeia Trichomanis (L.) Corda

Cephaloziaceae

*Cephalozia media Lindb.**

Harpanthaceae

Lophocolea heterophylla (Schrad.) Dumort.

Jungermanniaceae

Plectocolea crenuliformis (Aust.) Mitt.*

Plectocolea hyalina (Lyell) Mitt.

Plagiochilaceae

Plagiochila asplenioides (L.) Dumort.

Scapaniaceae

Scapania nemorosa (L.) Dumort.

Porellaceae

*Porella platyphylloidea (Schwein.) Lindb.**

Frullaniaceae

Frullania eboracensis Gottsche

Blasiaceae

Blasia pusilla L.

Marchantiaceae

Marchantia polymorpha L.

Conocephalum conicum (L.) Dumort.

Rebouliaceae

Reboulia hemisphaerica (L.) Raddi

Anthocerotaceae

Anthoceros laevis L.

MUSCI

Sphagnaceae

Sphagnum sp.

Tetraphidaceae

Tetraphis pellucida Hedw.

Fissidentaceae

Fissidens cristatus Wils.

Fissidens osmundioides Hedw.

Fissidens subbasilaris Hedw.

Fissidens taxifolius Hedw.

Fissidens viridulus (Web. & Mohr) Wahlenb.

Ditrichaceae

Ceratodon purpureus (Hedw.) Brid.
Ditrichum pallidum (Schreb., Hedw.) Hampe.

Dicranaceae

Dicranella Heteromalla va. orthocarpa (Hedw.)
Dicranella varia (Hedw.) Schimp.
Dicranum scoparium (L.) Hedw.

Leucobryaceae

Leucobryum glaucum (Hedw.) Schimp.

Polytrichaceae

Atrichum angustatum (Brid.) Bry. Eur.
Atrichum undulatum (Hedw.) Beauv.
Pogonatum pensilvanicum (Hedw.)
Polytrichum commune Hedw.
Polytrichum juniperinum Hedw.
Polytrichum ohioense Ren. & Card.

Buxbaumiaceae

Diphyscium foliosum (Hedw.) Mohr

Pottiaceae

Barbula fallax Hedw.
Desmatodon obtusifolius (Schwaegr.)
Gymnostomum calcareum Nees. & Hornsch.
Weisia viridula Hedw.

Grimmiaceae

Grimmia apocarpa (L.) Hedw.
Hedwigia ciliata (Ehrh) Hedw.

Funariaceae

Funaria hygrometrica (L.) Hedw.
Physcomitrium turbinatum (Mx.) Brid.

Orthotrichaceae

Drummondia prorepens (Hedw.) Jennings
Orthotrichum pumilum Dicks.

Aulacomniaceae

Aulacomnium heterostichum (Hedw.) Bry. Eur.

Bartramiaceae

Bartramia pomiformis (L.) Hedw.

Bryaceae

Bryum argentum L.
Pohlia nutans (Schreb.) Lindb.
Pohlia Wahlenbergii (Web. & Mohr.)
Rhodobryum roseum (Weis.) Limpr.

Mniaceae

Mnium affine Bland.
Mnium cuspidatum Hedw.
Mnium punctatum (L.) Hedw.
Mnium spinulosum (Br. & Sch.) Bry. Eur.

Hypnaceae

Amblystegium varium (Hedw.) Lindb.
Brachythecium acutum (Mitt.) Sull.
Brachythecium oxycladon va. dentatum (Lesq. & James) Grout
Brachythecium *plumosum* (Sw.) Br. & Sch.*
Brachythecium rivulare Bry. Eur.
Brachythecium salebrosum (Hoffm.) Br. & Sch.
Bryhnia gramnicolor (Brid.) Grout
Calliergonella Schreberi (Willd., Br. & Sch.) Grout
Campylium chrysophyllum (Brid.) Bryhn
Campylium hispidulum (Brid.) Mitt.
Cirriphyllum Boscii (Schwaegr.) Grout.
Climacium americanum Brid.
Entodon cladorrhizans (Hedw.) C. Muell.
Entodon seductrix (Hedw.) C. Muell.
Eurinchium serrulatum (Hedw.) Kindb.
Homomallium adnatum (Hedw.) Broth.
Hygroamblystegium fluviatile (Hedw.) Loeske
Hypnum curvifolium Hedw.
Plagiothecium denticulatum (L. Hedw.) Bry. Eur.
Plagiothecium geophilum (Aust.) Grout
Plagiothecium *Roseanum* (Hampe) Bry. Eur.*
Platygyrium repens (Brid.) Bry. Eur.
Sematophyllum *carolinianum* (C. Muell) E. G. Britton*

Leskeaceae

Anomodon attenuatus (Hedw.) Huben
Anomodon minor (P. B.) Lindb.
Anomodon rostratus (Hedw.) Schimp.
Leskea polycarpa (Hedw.)
Thelia asprella Sull.
Thuidium delicatulum (L. Hedw.) Mitt.
Thuidium pygmaeum Bry. Eur.

Hookeriaceae

Hookeria *acutifolia* (Hook.) Schwaegr.*

Leucodontaceae

Leucodon julaceus (Hedw.) Sull.

NOTE: The author believes that this is the first time the italicized species have been reported from Illinois. P. platyphylloidea has been collected often, but, according to Dr. Steere, has been called P. platyphylla. Dr. Hague states that S. carolinianum has been collected but not reported. Dr. Steere states that this report on H. acutifolia marks a considerable extension of the range of this moss as it has not previously been reported west of Ohio.

THE TREES OF ADAMS COUNTY, ILLINOIS

Robert A. Evers

Quincy Junior High School, Quincy, Illinois

Since there are a number of people in the state who are interested in the distribution of plants in Illinois, perhaps it would be well to publish a list of trees found in Adams County in order to bring the distribution record up to date.

This list of arborescent plants was compiled from herbarium specimens in the University of Illinois, the Natural History Survey Herbarium; and from the card index in the Natural History Survey which lists Illinois plants found in the herbaria of Field Museum, Northwestern University, and the Missouri Botanical Garden. Only seven different species were found in these herbaria, the remainder of the species in this list resulted from the author's collection made in Adams County since the autumn of 1939. The nomenclature used is chiefly that of Rehder's "Manual of Cultivated Trees and Shrubs", second edition, 1940.

No initial after the name of the plant in the following list indicates that the specimens are in the author's collection now in the herbarium of the University of Illinois and in other herbaria. An initial in parentheses indicates an herbarium specimen other than the author's in some herbarium: (F), Field Museum; (NHS), Natural History Survey; (UI), University of Illinois. The collector's name follows the herbarium abbreviation. If the initial is preceded by the ampersand (&), the author also collected this species.

Pinaceae

Juniperus virginiana L.

Salicaceae

Populus alba L. Escaped cultivation.
Populus deltoides Marsh.
Salix alba L (An escape)
Salix amygdaloides Anders.
Salix nigra Marsh.
Salix interior Rowlee
& (F). Beckwith, 1916.

Juglandaceae

Juglans nigra L.
Juglans cinerea L.
Carya Pecan Engl. & Graebn.
Carya cordiformis (Wangh.) K. Koch
& (UI). Seymour
Carya glabra (Mill.) Sweet
Carya laciniosa (Michx. f.) Loud
Carya ovata (Mill.) K. Koch
Carya tomentosa Nutt.

Betulaceae

Betula nigra L.
& (NHS). Pepoon & Barrett, 1932.
Carpinus caroliniana Walt.
Ostrya virginiana (Mill.) K. Koch

Fagaceae

Quercus imbricaria Michx.
Quercus marilandica Muenchh.
Quercus velutina Lam.
Quercus palustris Muenchh.
Quercus borealis var. *maxima* Ashe
Quercus alba L.
Quercus stellata Wangh.
Quercus macrocarpa Michx.
Quercus muhlenbergii Engelm.

Ulmaceae

Ulmus americana L.
Ulmus fulva Michx.
Celtis laevigata Willd.
Celtis occidentalis L.
Celtis occidentalis var. *crassifolia*
(Lam.) Gray

Moraceae

Morus alba L. Escaped cultivation.
Morus rubra L.
Maclura pomifera (Raf.) Schneider

Anonaceae

Asimina triloba Dunal & (UI). Gates, 1916.

Lauraceae

Sassafras albidum (Nutt.) Nees

Platanaceae

Platanus occidentalis L. & (NHS). Pepoon & Barrett, 1932.

Rosaceae

Crataegus mollis Scheele
Crataegus viridis L. & (UI).Davis, 1912.
Crataegus Crus-galli L.
Crataegus punctata Jacq. (UI). Seymour, 1878.

Amelanchier canadensis (L.) Medic.
Malus ioensis (Wood) Bailey
Prunus hortulana Bailey
Prunus serotina Ehrh.
Prunus lanata (Sudw.) Mack & Bush

Leguminosae

Cercis canadensis L.
Gleditsia triacanthos L.
Gymnocladus dioicus (L.) K. Koch
Robinia pseudoacacia L.

Rutaceae

Ptelea trifoliata L.

Simaroubaceae

Ailanthus altissima (Mill.) Swingle

Aquifoliaceae

Ilex decidua Walt.

Celastraceae

Euonymus atropurpurea Jacq.

Aceraceae

Acer saccharinum L.
Acer saccharum Marsh.
Acer Negundo L.

Hippocastanaceae

Aesculus glabra Willd.

Tiliaceae

Tilia americana L.

Cornaceae

Cornus alternifolia L. f. (NHS).
Pepoon & Barrett, 1932.

Ebenaceae

Diospyros virginiana L.

Oleaceae

Fraxinus americana L.
Fraxinus pennsylvanica Marsh.
Fraxinus pennsylvanica var. *lanceolata* (Borkh.) Sarg.
Fraxinus quadrangulata Michx.
Forestiera acuminata (Michx.) Poir.

Bignoniaceae

Catalpa speciosa Warder.
Escaped cultivation.

Caprifoliaceae

Viburnum prunifolium L.

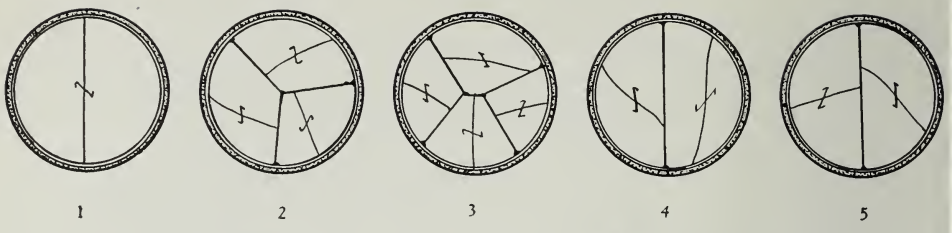
MULTI-SEEDED ACORNS

J. T. Buchholz, *University of Illinois, Urbana, Illinois*

At Conway, Arkansas is a large native tree of Southern red oak *Quercus falcata* Michx* which is very unusual in that it bears acorns that contain several seeds each. This tree stands on a corner lot bordered by Bruce Street on the north and by Davis Street on the east. It was originally located in the fall of 1917 as a result of a survey of the acorns falling from hundreds of trees in this section of Conway. Only very rarely was an acorn found elsewhere with more than a single seed. Under this tree and one other, a great majority of the fruits were multi-seeded. The other tree, a much smaller one, was located in a grove about a block or more north and a similar distance west not far from the east bank of a brook, and may have been cut down in the development of this area as a residential section.

The tree at Bruce and Davis streets differs in no obvious particulars from hundreds of other native trees of this variable species. It differs only in the structure of its fruit. The acorns are abnormal in containing several seeds that are crowded into the space usually occupied by a single seed. When these acorns are planted several seedlings emerge from the nut instead of the usual single seedling. I suspect that there are other differences that no one has observed. One may be in its physiological vigor of growth, especially of the acorns. However no claim is advanced that this tree is another species or even a variety. Like several of the synonyms given for the species*, this tree may be a sub-variety or form, and is very likely to represent a mutation, but before the term mutation may be applied, the inheritance

* Given as *Quercus rubra* L. in the writer's pocket manual of the Common Forest Trees of Arkansas (Little Rock 1924). As a result of changes and clarification of the International Rules of Botanical Nomenclature (1930, 1935) the name *Q. rubra* L. does not remain as the legitimate name of any North American species. The name *Q. falcata* Michx. remains the legitimate botanical name of the Southern red oak, also called Spanish oak, and the following are synonyms: Q. rubra L. not DuRoi., Q. triloba Michx. Q. digitata Sudw., Q. cuneata Rehd. and Q. pagodaefolia Ashe. At least the last named is recognized as a variety: Q. *falcata* var *pagodaefolia* Elliott and it is likely that other varieties should be recognized. The names of other oaks given by Buchholz and Mattoon (1) remain unchanged by the rules.



Diagrams Showing Cross Sections of Normal and Multi-seeded Acorns x2
1. Normal acorn with single seed. 2. A 3-seeded acorn. 3. A 4-seeded acorn. 4 and 5. 2-seeded acorns. Pairs of cotyledons belonging to same embryo are connected by a "z".

of this multi-seeded condition would have to be demonstrated.

The structure of flowers in the oak and the development of the fruit was described nearly a century ago by the German botanist Theodor Hartig (5). The subject is treated more briefly by M. Marshall Ward (7) in *The Oak*, one of the Modern Science Series edited by Sir John Lubbock (Lord Avebury). Every female oak flower contains 6 ovules within its compound tricarpellate pistil. Though the ovary has a single cavity these ovules are attached to 3 marginal placentae in pairs, and become, for a time, so crowded and pushed together that it gives the impression of a 3-celled ovary. At the time of pollination the ovules are still very rudimentary and undeveloped, but they become well organized during the first season. In the summer of the second year (for it requires 2 seasons to mature the acorns of oaks belonging to the red oak group) the pistil enlarges very greatly to form the acorn. Usually only one of the six ovules enlarges and matures to form a seed; the embryo which it contains stretches its seed coat out thin as it fills the entire space within the pericarp. The other five ovules become aborted and are carried upward by the intercalary growth of the shell of the nut so that they may be observed only under magnification inside of the shell at the tip of the mature acorn or they may be seen clinging to the apex of the enlarged seed when this is removed from the shell. For some reason this Conway tree matures seeds from more than one of its ovules—as many as five out of a possible six seeds have been found.

The conditions shown by the acorns may be illustrated by the accompanying diagrams of the cross sections. Fig. 1 shows the cross section of the normal acorn in which only two cotyledons belonging to a single embryo may be seen. The heavy outer layer is the woody pericarp or shell of the acorn. This contains a seed which consists of a dicotyledonous embryo without endosperm, surrounded by a very thin papery seed coat. In fig. 2 there are three embryos, each of which is surrounded by a similar thin seed coat and the embryo of each seed has two cotyledons. Fig. 3 shows the section of an acorn with four seeds. Figs. 4 and 5 each show acorns having two seeds with embryos, with the lines of separation between the pair of cotyledons placed in various positions, indicating that there is no regularity in the radial orientation of the embryos. Sometimes the cotyledons are very unequally developed so that only one of a pair shows in a section cut through the base of the acorn. Several instances were found in which a cross section cut below the middle of the nut showed only two cotyledons, which upon further dissection proved to have additional seeds with embryos, very much smaller and crowded up toward the apex of the nut. All embryos are oriented with the radicle brought close to the apex of the acorn. When the shell of the acorn is completely removed the individual seeds usually fall apart and show how each embryo is surrounded by an individual seed coat.

77 acorns of the 1940 seed crop collected from beneath this tree were carefully examined during the past winter. 40 of these were normal while 37 contained two or more seeds each. As I recall, in 1917 there were more acorns with abnormal seeds. However if only the larger nuts were sampled in 1917, the proportion of abnormal seeds would have been higher, as I shall show presently. Among the 37 acorns with more than one seed, 14 had 2, 10 had 3, 11

had 4 and 2 had 5 seeds. The 37 abnormal acorns in the 1940 sample contained an average of 3 seeds.

In the summer of 1918, after leaving Conway, the writer received at intervals of 2 weeks during June and July, collections of twigs bearing developing acorns from this tree along with collections made from another red oak tree of similar size nearby and known to bear only normal fruit. These were dissected and compared in similar stages of development. It was obvious from these investigations that in the tree with abnormal acorns more than one of the ovules enlarges and develops to maturity. In the tree with normal fruits the development of five of the six ovules was checked very early in the second season. Another difference was noted: the fruits of the abnormal tree were usually larger at any of these mid-season dates than in the tree that had been chosen as a control. However the mature acorns were not noticeably larger than those of other trees of *Quercus falcata*. Possibly this more precocious growth of the fruit has something to do with the development of several seeds per acorn, in furnishing more room at a critical stage for the enlargement of several ovules to form seeds.

Mr. J. H. Gist who collected the samples of seeds of the 1940 crop informed me that the tree, now nearly 3 feet in diameter, had been pollarded in recent years. All of the 1940 crop of fruits was produced on a dense new growth of slender branches arising from the stubs of large limbs. The acorns were on the whole smaller than the average size for acorns of *Quercus falcata*, as I remember them, and were quite variable in size. Their diameters ranged from 8.5 mm to 12.5 mm; their mean diameter was 10.5 mm. Among 33 acorns which measured more than 10.5 mm indiameter there were 24 (77%) with 2 or more seeds; among 44 acorns 10.5 mm in diameter or less, only 13 (30%) had 2 or more seeds. In the larger group of acorns the mean number of seeds per fruit was 2.5; in the smaller group of 44 the mean was 1.5 seeds per fruit. It is possible, therefore, that the impression gained in 1917 of a greater prevalence of the multi-seeded condition was correct, but was based on seed samples which included larger seeds.

There are some records in the literature of this condition, based upon observations of the germination of more than a single seedling from an acorn. Harvey (6) mentioned an example in the white oak (*Quercus alba* L.), which he appears to have misinterpreted as an instance of polyembryony. Similar observations have been reported for other species and described as polyembryony; even Coulter (4) appears to have accepted this interpretation. However, polyembryony, which involves several embryos which are formed within the same seed, would be very difficult to prove for the oak. It could certainly not be proved in the later stages represented by germinating acorns. Many years ago Coker (2, 3) recognized and described this condition on the basis of germinating acorns. He mentioned a tree of basket oak, *Q. prinus* L., near Baltimore, and a tree of white oak, *Q. alba* L., at Chapel Hill, North Carolina, in both of which many acorns give rise to several seedlings each. He also found a single instance of a multi-seeded acorn in the black oak, *Q. velutina* Lam.

The condition found in the tree at Conway might occur sporadically in any species of oak, for they all have six ovules in the pistil. The explanation that abnormalities similar to the one reported by Harvey are due to multi-seeded acorns is more logical and more natural. The interesting feature which concerns the tree at Conway is the fact that this condition has persisted over a period of 23 years, even after severe pruning of the upper branches.

1. Buchholz, J. T. and W. R. Mattoon. Common Forest Trees of Arkansas. Little Rock. 1924.
2. Coker, W. C. Multi-seeded acorns. Bot. Gaz. 37:61-62. 1904.
3. Coker, W. C. The seedlings of the live oak and the white oak. Jour. Elisha Mitchell Sci. Soc. 28:34-41. 1912.
4. Coulter, J. M. Polyembryony. Bot. Gaz. 64:184. 1918.
5. Hartig, Theodor. Naturgeschichte der förstlichen Kultur-Pflanzen Deutschlands. Berlin. 1851.
6. Harvey, LeRoy H. Polyembryony in *Quercus alba*. Mich. Acad. Sci. Rept. 19:329-331. (1917.)
7. Ward, H. Marshall. The Oak. New York. 1900.

GEMMAE OF *FUNARIA HYGROMETRICA*

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Although the gametophyte and the sporophyte of *Funaria hygrometrica* have been studied as much, or more, than any other moss, little attention has been given to the development, structure and regeneration of the gemmae. Janzen (5), Correns (2), Goebel (3), and Schimper (6) have observed, mentioned and/or illustrated what they termed "Brutkörper" or "Brutknollen." "Brutknollen" of *Funaria*, illustrated by Schimper, do not resemble those observed in this study. (1) "Brutkörper," similar to those of *Funaria*, have been observed in other mosses (2, 3, 6, 7).

Capsules of *Funaria hygrometrica* were collected one-half mile west of Burn's Ditch Bridge on route U. S. 12 on the south side of the highway during June, 1937. The spores of these capsules were sown on damp, sterilized soil in 5 inch deep, 9-inch flower pots, and covered with specially made celluloid lids which permitted adequate ventilation. All cultures were watered from below with a weak potassium permanganate solution.

The average size of a protonemal cell from a soil culture is 18 microns in width by 73 microns in length. On or near the 28th day after the spores were sown many of the terminal cells of the protonema had developed gemmae. While the cells of the protonema vary greatly in length, it is apparent that from one to several of these cells may have participated in the development of gemmae (figs. 1-2). Cross walls were laid down at rather regular intervals cutting the original cell, or cells, into short ones which, when elongated, were about 51 microns. These short cells grew in width to 44 microns. Thus those newly formed were nearly isodiametric. Frequently, very short ones occurred separating several short cells in the branch from others. These shorter cells were sometimes well supplied with chloroplasts and at other times hyaline. When hyaline the branch easily broke away from the remaining cells. Within a few hours after walls had been formed at right angles to the axis, other walls parallel to the axis were laid down. Often a single short cell divided twice longitudinally. Other cells divided diagonally. Eventually, many of these newly formed cells became almost spherical or hemi-spherical. Cells remaining rectangular in outline were thicker through the center than on the edge.

Division continued until a column or a grape-like cluster was developed (figs. 3-5). These columns and clusters varied greatly in length, but some of the longest were not more than 250 microns to 300 microns. When young the cells were thin-walled and contained many chloroplasts. These columns and clusters were often branched and eventually were cut from the plant by a hyaline cell which, being brittle, separated the cluster from the plant at the slightest touch. Gurlitt (4) observed short hyaline cells in *Funaria hygrometrica*, which she called Trennzellen, since they separated a short living portion from another living portion of the protonema.

When transplanted to agar each thin walled cell of a gemmae regenerated a protonema within 28 days during the short cloudy days of winter. In the summer such cells taken from the apex of a leafy plant were mounted in water on a slide and kept in a moist chamber. Within 20 hours after mounting, the terminal cell of many of these groups had regenerated a protonema. By the time leafy plants were well established these structures and the remainder of the protonema had disappeared.

During an interval when the work was discontinued, ten 9-inch flower pots containing soil cultures of *Funaria* were stacked in a column in a corner of a room in the University of Chicago greenhouses. In May all but one of these appeared dead and were discarded. The one showing some life was watered and placed in the room exposed to the sunlight. This culture soon appeared to be dead and the pot was pushed under a low greenhouse table and left unattended until July 21, when it was again watered and placed in a cool room of the green-

house under diffused light. Four days later signs of life were evident. Microscopic examination disclosed gemmae similar to those described above. They differed in several respects from those previously observed (figs. 1-4). They were dark brown in color, without chloroplasts, and possessed thick cell walls in contrast to the thin walls of the cells well supplied with chlorophyll which appeared early in the life history of the plant (Figs. 6-8). The apparent rejuvenation of this culture was the result of the germination of these structures (fig. 10). A few chloroplasts had by this time appeared in the old cells of the germinating gemmae.

In the summer of 1940 plants bearing mature gemmae were placed on agar and covered with the Petri dish cover. A day later young leafy plants had developed directly from these gemmae. Observations indicate that protonemata develop from either young or mature gemmae of few cells, but leafy plants develop directly from the more complex mature gem-

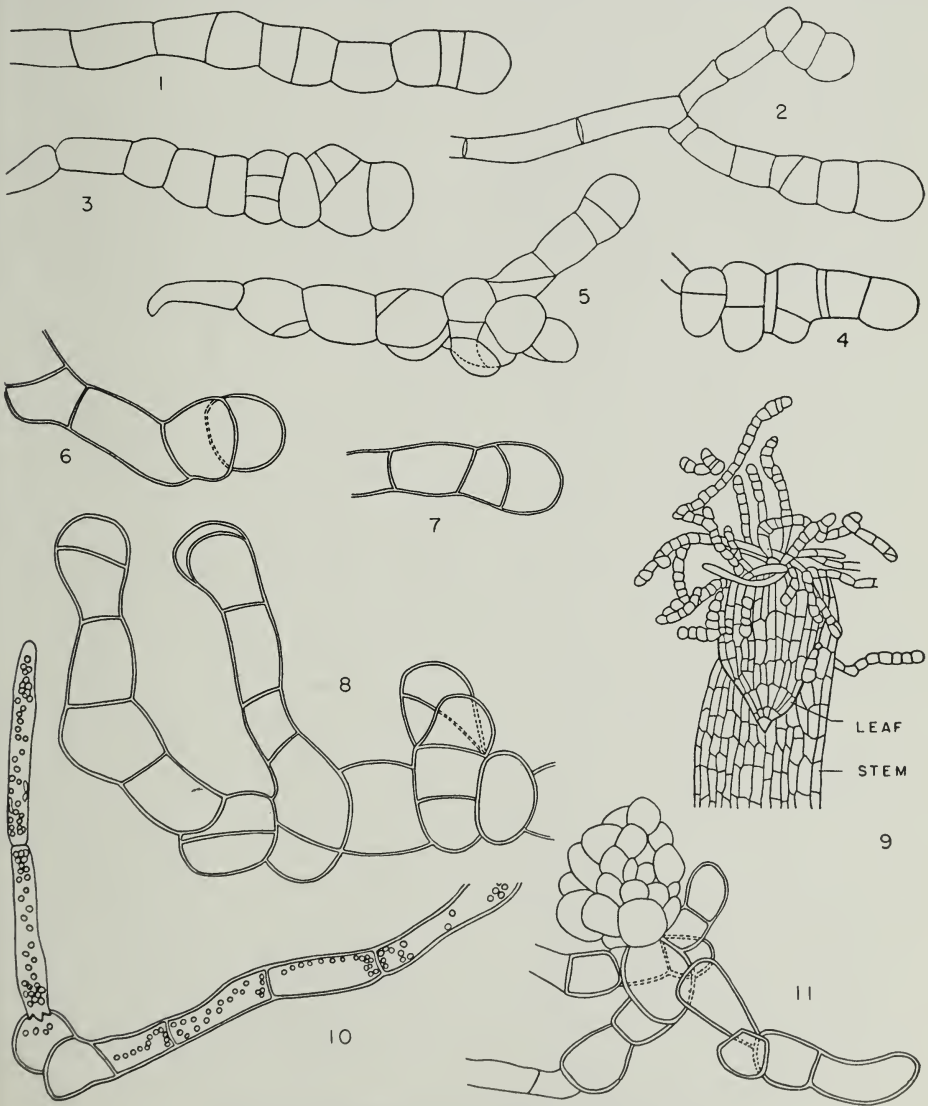

PLATE I.—GEMMAE OF *Funaria hygrometrica*.

mae, that is, from those clusters composed of a number of thick walled, brown cells, (fig. 11). Such gemmae have been known to be viable for as long as eight months.

Gemmae play an important role in the life of *Funaria*. Examination of moss tufts preserved during late winter revealed a dense thicket of young gemmae growing from the main axis of each plant. The culture from which this material was taken had been unattended for more than a month. In the fall of the same year a healthy, covered culture was left unwatered. A month later gemmae were again established on the axis of the plants. This same culture was left in a school laboratory during the year and watered occasionally. The culture grew brown and in June the plants appeared dead. In June this pot was again placed under favorable conditions in the University of Chicago greenhouses. The brown, dried apices of the much branched plants turned green and grew a new crown of leaves. In cases where most of the old apex had been destroyed a multitude of gemmae developed (fig. 9). Thus in a favorable environment *Funaria hygrometrica* may continue to thrive indefinitely even without the aid of spores.

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A LIST OF DIAGNOSTIC CHARACTERISTICS FOR DESCRIPTIONS OF DICOTYLEDONOUS WOODS

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During the course of investigations of the wood anatomy of a number of dicotyledonous families (23, 24), the writer has had occasion to compile an extensive list of the important diagnostic features of wood. In the belief that this compilation may be of use to beginners, and perhaps of some interest to professional wood anatomists, the writer has prepared it for publication. This catalogue includes the important phylogenetic features (5, 14, 15, 16, 17, 23) as well as those whose phyletic value is not yet established, but yet which have proven to be of taxonomic import.

As far as the writer knows, but two other lists of this character have been published. Clarke (11) has designed a short list for a card sorting device and Record and Chattaway (19) have published a more extensive list for the same purpose.

Frequent citations of the more important, especially the more recent, papers have been made throughout the present list. Particular attention should be drawn to the important "Glossary of terms used in describing woods" (12) prepared by the Committee on Nomenclature of the International Association of Wood Anatomists and to the books by Record (18) and Brown and Panshin (3).

LIST OF DIAGNOSTIC FEATURES.

Name of plant (indicate if young or mature by Y or M).
Number of wood.
Geographical distribution.
Growth rings—present or absent.
  Width in μ (measure 10 or more).
    Range — Example: 30-40 μ
    Most frequent range — 35-38 μ
    Mean — 37 μ
Tracheids and fibers.
  Tracheids—(See 2).
    Ordinary type.
    Vasicentric tracheids.
    Vascular tracheids.
  Fiber-tracheids.
  Septate fiber-tracheids.
  Libriform wood fibers.
  Septate wood fibers.
  Gelatinous fibers.—(See 20).
  Wall thickness (radial wall)—(See 9).
    Very thin—lumen much greater than thickness of walls.
    Thin—lumen greater than thickness of walls.
    Thick—lumen less than thickness of walls.
    Very thick—lumen almost completely closed.
  Size of pits—measure at least 10.
    Minute.
    Small.
    Large.
  Length—measure 100 from macerations (Record No. of measurements) (See 13, 21, 22).
    Range.
    Most frequent range.
    Mean, with standard error.
      Standard deviation, with standard error.
  Spiral thickenings, present or absent.
Vessels
  Number per sq. mm. (in X-section)—count 10 or more fields.
    Range.
    Most frequent range.
    Mean.
  Pore distribution.
    Solitary pores. } Record % in each category
    Pore multiples. } and no. of pores in the group-
    Pore clusters. } ings. (Ex. clusters $90\%^{2-4}$).
    Pore chains. } Sample 10 or more fields.
  Diffuse-porous.
  Semi-ring-porous.
  Ring-porous.
  Angular or circular in X-section.
  Thin or thick wall—measure a few walls.
  Diameters—measure 100 in X-section (tangential diameter).
    Record no. of measurements. (See 9, 13, 21, (22). If ring-porous, take 50 in the early wood and 50 in the late wood.
    Range.
    Most frequent range.
    Mean, with standard error.
      Standard deviation, with standard error.
  Tyloses, present or absent.
    Few or many in sections.
    Few or many in individual vessels.
    Thin or thick walls (sclerotic).
    Contents.
    Pits.
  Perforation plates—(See 14).
    Exclusively scalariform.
    Scalariform and simple.
    Simple and vestiges of scalariform.
    Simple.
    Reticulate—(See 4).
    Foraminate
  Number of bars (in scalariform perforation plates).
    Range.
    Most frequent range.
  Width of perforations (if scalariform).
    Range.
    Mostly.
  Perforations bordered or not (if scalariform)—(See 15).
    Complete border.
    Border to middle.
    Border at ends.
    Non-bordered.
  End walls.
    Oblique—express as angle. (Ex. 50° -80°).
    Transverse.
  Intervascular pitting—(See 16).
    Scalariform.
    Transitional.
    Opposite.
    Alternate.
    Sparse or crowded.
    Size of pits—(See 19).
      Minute—less than 4 μ
      Small—less than 7 μ
      Medium—7-10 μ
      Large—over 10 μ
      Very large—over 15 μ
    Shape of pits.
      Circular.
      Square.
      Pentagonal, etc.
  Gum deposits in vessels.
    Color, abundance, location.
  Striations on vessels.

Vessel-parenchyma pitting.
Scalariform.
Transitional.
Opposite.
Alternate.
Size—(See 19).
Fine—not more than 7 μ
Medium—7 to 10 μ
Coarse—more than 10 μ
Shape.
Circular, oval, elongated.
Unilaterally compound.
Length of vessel elements (total body length)—(Measure 100 from macerations). Record No. of measurements. (See 7, 13, 21, 22).
Range.
Most frequent range.
Mean, with standard error.
Standard deviation, with standard error.
Spiral thickenings.
Vascular rays.
Abundance—No. per mm. (tangential section).
Type—(See 17).
Heterogeneous I.
Heterogeneous IIA.
Heterogeneous IIB.
Heterogeneous III.
Homogeneous I.
Homogeneous II.
Homogeneous III.
Width (No. of cells wide).
Range.
Most frequent range.
Height.
Uniseriate rays.
Range.
Most frequent range.
Multiseriate rays.
Range.
Most frequent range.
Pitting (between ray cells and other parenchyma cells).
Size.
Number—few, many, clustered.
Lignified, or not.
Perforated ray cells—(See 6).
Intercellular canals.
Latex tubes.
Oil cells.
Crystals-type, etc.
Aggregate rays.
Sheath cells.
Tile cells.
Sclerotic ray cells.
Xylem parenchyma
Abundance.
Sparse, abundant, or absent.
Distribution—(See 12).
Diffuse.
Terminal.
Initial—(See 10).
Metatracheal—record No. of cells wide.
Vasicentric.
Aliform.
Confluent.
Pitting (between xylem parenchyma cells.).
Size.
Number—few, many, or clustered.
Fusiform parenchyma cells.
Septate parenchyma cells.
Chambered parenchyma cells.
Crystals—type, etc.
Lignified.
Sclerotic parenchyma cells.
Other Features.
Storied structure—state which elements.
Crystals present.
Location, type, etc.
Pith flecks.
Intercellular canals (gum, resin, or oil).
Vertical or horizontal, or both.
Normal or traumatic.
Included phloem—(See 8).
Vestured pits (in vessel elements, tracheids, or fiber tracheids)—(See 1).
Fibriform vessel members—(See 25).
Disjunctive tracheids.
Disjunctive parenchyma cells.
Photographs.
Indicate slide and location on slide.

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TECHNIQUES USEFUL IN THE STUDY OF FOSSIL PLANTS

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ABSTRACT

Many techniques have been worked out after long hours of experimentation in the various paleobotanical laboratories throughout the world. Oftentimes the new methods are never published nor passed on to other workers. It is our purpose here to bring to light or revive some of those techniques which we have found most valuable in recent years in our laboratories. A few of the old techniques have been greatly modified, later ones have been elaborated upon and new ones have been discovered.

It is often advisable to prepare casts and molds to preserve a record of the original condition of the material if it is found necessary to section the specimens for proper study. Air drying liquid rubber has recently been developed which may be applied to the specimen as a paint. After the desired thickness has been attained, a backing of cheesecloth is imbedded in an additional coat of rubber to make the mold hold its shape permanently. The rubber mold may then be removed by lifting a corner and stripping it off. This mold preserves even the most minute details of the surface configuration including overhangs, and will never lose its shape. It is often advisable to make a plaster cast of the back of the rubber mold in which it may be placed to facilitate making positive casts later.

The rubber mold should be dampened just before pouring the plaster into it in order that the plaster will not be withheld from minute surface markings by air bubbles. (Dip the mold in water and then remove all frée water with a gentle stream of air.) A fine grade of plaster should be used. The rate of setting of the plaster may be slowed by using ice cold water. A strong solution of salt water will slow it even more. Gum arabic or glue may be added to the solution to make the cast stronger. Water soluble paints of the desired color, i.e. the one most nearly simulating the matrix, may be suspended in the water before mixing it with the plaster. The plaster, when poured, should have the consistency of molasses, i.e. thick but not stiff.

A method of enlarging casts of specimens bearing definite surface configurations or of definite shape has been worked out. The rubber molds are made of the original specimen in the same way as those already described except that the cheesecloth backing must be omitted. The molds are then placed in kerosene and allowed to remain until they have expanded to about one and one-half times their original size. The mold is then carefully lifted out, the excess kerosene is taken up with a blotter and it is placed in a sand mold. This sand backing is almost necessary, for the rubber has lost much of its tensile strength and would break down under the weight of the plaster if unsupported. A plaster cast is then made of the rubber mold. From this enlargement another rubber mold may be made and the step repeated a number of times. Expansion is quite uniform throughout the rubber so that distortion in the enlargements is almost non-existent. If the first mold is taken from a plaster cast which has been colored as described above, part of the color will be transferred accurately to succeeding enlargements for about three or four steps.

Photographing original specimens is sometimes difficult due to surface markings or mineral coloration. If the rubber mold of the original specimen is colored uniformly white by the precipitate of the fumes given off when ammonium chloride is heated in an ammonium chloride tube, a picture may be made of the mold and these difficulties are overcome. It is best to overexpose and underdevelop both the negative and the prints. This increases the shadow and the contrast.

Friable or wet impressions or casts of fossils may be preserved in the field in several ways. Rubber molds may be made of large casts or material which may not be moved either because of size or condition. Smaller specimens may be completely imbedded in Duco Cement to hold them together. This may be dissolved off later with amyl acetate when preparing the material for study. Collodion and nitro-cellulose may be used to great advantage in imbedding dry material which is very friable. Nitro-cellu-

lose may be cheaply made by substituting movie film for parlodian or guncotton. The gelatin must be removed from the film with hot water before dissolving it in amyl acetate. Nitro-cellulose so made is equally as good as any other. A supersaturated solution of gum sandarac in water may be used to preserve material either wet or dry. This is the best preservative we have found for all around use and it is simple to make as well as inexpensive. It dries on the specimen into a clear, shiny film that is impervious to most acid fumes, water and dust. It does not shrink when put on a wet specimen as does nitro-cellulose.

Cutting and grinding specimens may be done in a number of ways. One recently improved upon in our laboratories is the use of fine wire with Aloxite or Carborundum powder as the abrasive. A board has been fitted to a vise in the following manner. Holes were bored into it to correlate with the position of the shaft of an ordinary commercial vise. The vise is then taken apart and the board inserted over the shaft which is then reassembled. At each end of the board, which extends about six inches on either side of the vise, a pulley is mounted rigidly upside down. The base of the pulley frame is cut out exposing the base of the pulley. The specimen to be cut is partially imbedded in sealing wax which may be clamped in the vise or fastened to the board. The wire is then drawn over one pulley, across the specimen and over the other pulley. These pulleys act as guides to insure a straight cut. Number 36 gauge steel or tinned wire is found to be quite suitable along with number 400 grade of grinding powder. With this simple device perfectly straight, almost polished cuts may be made with the loss of only about 175 microns of the material.

COMPOSITION OF THE GENUS CAREX IN ILLINOIS

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By specimens deposited in permanent herbaria and by reports in botanical literature, no fewer than 162 species of Carex have been credited to Illinois. A portion of these species, as is to be expected, have been erroneously recorded for the state, partly because of wrong determinations in a notoriously difficult genus and partly because, earlier, the species conceptions within the genus were highly imperfect. Nevertheless, there still are recorded for Illinois, quite reliably, a total of 130 species. This number is approximately 24.4 per cent of all species recognized by Mackenzie[1] for the entire North American Continent and exceeds by 23 species the number attributed by Deam[2] to the neighboring state of Indiana.

With its more than 2000 species the world over, Carex has been divided into a large number of subgenera. On the North American Continent 71 of its subgenera are represented, and in Illinois 40 are represented. In Illinois no single subgenus predominates: the best represented subgenus is the *Ovales*, with 14 species; next is the *Bracteosae*, with 13 species; and third is the *Laxiflorae*, with 10 species. There are 4 subgenera represented by 6 species each, 2 by 5 species each, 3 by 4 species each, 6 by 3 species each, 7 by 2 species each, and 15 by 1 species each.

Of species and varieties at present recognized as valid, *Carex gravida* Bailey, *C. Bebbii* Olney, *C. tribuloides* var. *sangamonensis* Clokey, *C. Meadii* Dewey, *C. rectior* Mack., and *C. subimpressa* Clokey were originally named and described from specimens collected in Illinois. *C. Typhina* Michx., the name and description of which dates back to 1803, is recorded as having been found "*in regione Illinoensi.*"

No single species of Carex is confined in range to the state of Illinois. However, one species, *C. subimpressa* Clokey, is at present known only from Illinois and Indiana.

The majority of species are of wide range and reach into or pass through Illinois from other regions which can be deemed their principal ranges. Of 109 such species, Fig. 1, 35 extend into or through Illinois from the north, 25 from the northeast, 24 from the east, 5 from the southeast, 9 from the south, 2 from the southwest, 6 from the west, and 3

[1] Mackenzie, Kenneth Kent. Cyperaceae. In North American Flora, vol. 18, parts 1-7, pp. 1-478. 1931 and 1935.

[2] Deam, Charles C. Flora of Indiana. Indiana State Department of Conservation, Indianapolis. 1940.

from the northwest. The obvious preponderance of northern, northeastern and eastern species in Illinois could be explained as being due to the situation of the state near the western edge of the deciduous forest formation.

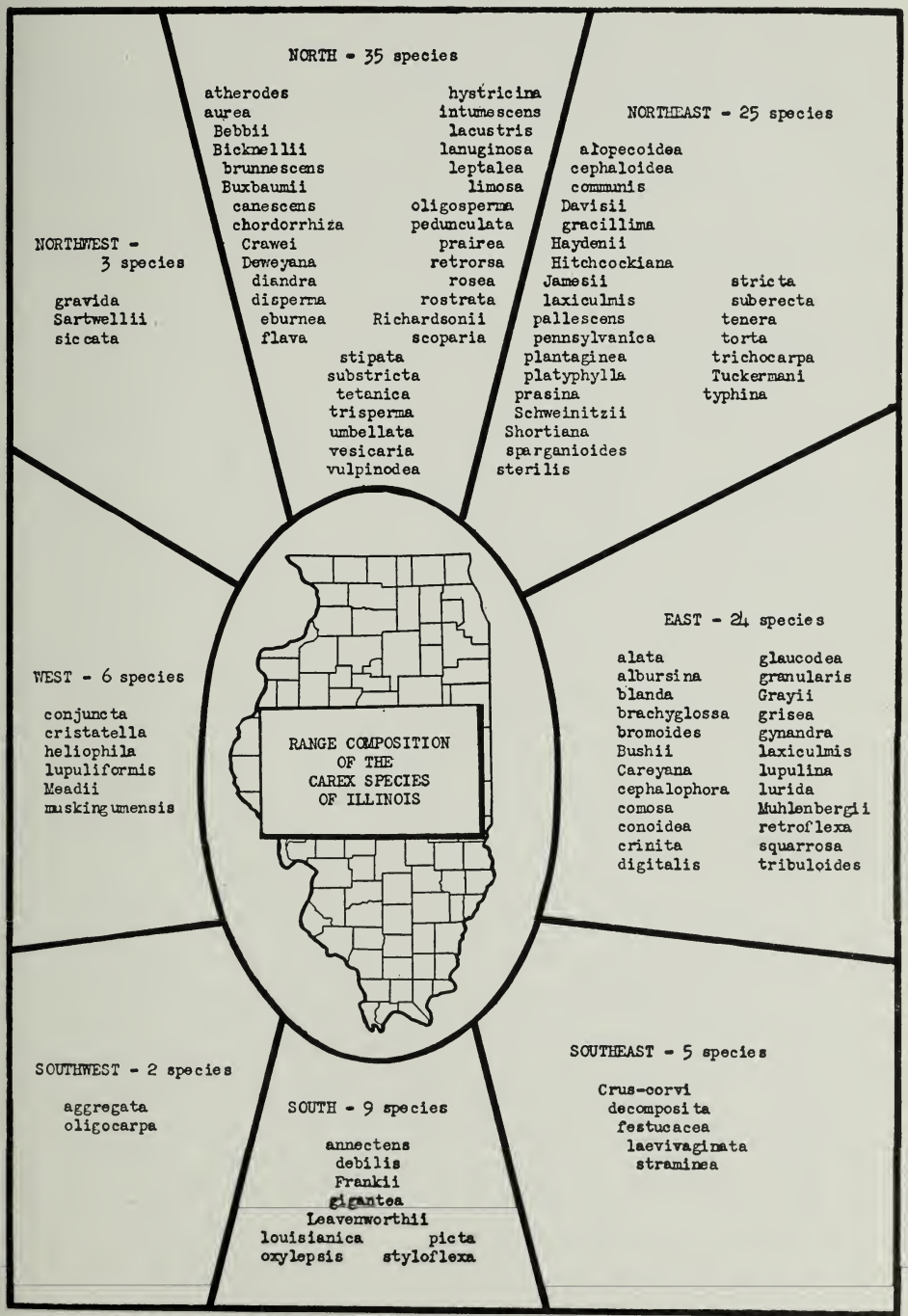

Fig. 1.—General ranges of 109 of the species of Carex composing the genus in Illinois.

Papers in Chemistry

Extract From the Report of the Section Chairman

The Evanston meeting carried 13 papers, 10 of which are herewith published. The others were:

Egloff, Gustav, and P. M. Arsdell, *Universal Oil Products Co., Chicago*—Some modern products of the oil industry.

Seiler, Frank J., *Galesburg High School, Galesburg*—Dehydration of hydrated $CdBr_2 \cdot 4H_2O$.

Schmeing, G. M., *Loyola University and Mundelein College, Chicago*—The connotation of the word "Chance" as employed in elementary physical chemistry and precautions urged to prevent misconceptions.

Maximum attendance was 71. Chairman elected for the Urbana meeting in 1942 was N. D. Cheronis, 5556 Ardmore Ave., Chicago.

(Signed) George H. Reed, *Chairman*

HYDROGEN FLUORIDE AS A CONDENSING AGENT

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The structures, H_2F_2 H_6F_6 and HF. which have at various times been assigned to gaseous hydrogen fluoride have been shown by recent electron diffraction measurements to be incorrect and incomplete. The new data indicate that the gas consists of polymers of indefinite length arranged in zig-zag fashion.

The use of hydrogen fluoride has been exploited mainly in connection with catalysis. It has been found that the catalytic alkylation of benzene can be effected in its presence. A great variety of alkylating agents can be used including olefins, alcohols, halides, ethers and esters. With the latter, acylation can also be accomplished simultaneously. As a rule tertiary and secondary halides, acohols and ethers will react at room temperature, whereas with the compounds of the primary type elevated temperatures are necessary.

It has also been observed that acylations occur in the presence of this catalyst. For example, acetophenone was produced from the interaction of acetic anhydride with benzene at 100° in the presence of hydrogen fluoride. Some acylations may proceed at ordinary temperatures. Generally polycyclic rings must be present before reaction will take place under the milder procedure. The simpler aromatic rings are acylated at 100°. Acid chlorides, anhydrides or carboxylic acids themselves are all equally capable of undergoing this reaction.

The mechanism of the alkylation reaction is as yet unknown. On the basis of present evidence it is fairly certain that neither olefins nor fluorides may act as the active intermediates in the condensation. It is proposed that a carbonium ion resulting from the ionization of the alkylating agent is the one that so far most satisfactorily accounts for all the observations. The ionization may proceed in the following manner;

$$RX + HF \leftrightarrows R{-}X{\rightarrow}H{-}F \rightleftarrows R^+ + X{\rightarrow}H{-}F^-$$
$$R^+ + C_6H_6 \longrightarrow R{-}C_6H_5 + H^+$$

Existing evidence seems to indicate that to a large extent the stability of the $X{\rightarrow}H{-}F^-$ ion determines the ease with which the reaction proceeds.

THE SURFACE TENSION OF STRONG ELECTROLYTES

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The surface tension of any interface must be interpreted first with respect to the Gibbs absorption equation which, in the general case, is

$$d\gamma = -\Sigma_i \Gamma_i \, d\mu_i \qquad (1)$$

For a simple binary system containing water and one solute, (1) can be written

$$d\gamma = -\Gamma \, d\mu \qquad (2)$$

where Γ is the adsorption of the solute at the interface, and μ is the chemical potential of the solute. The adsorption is defined by the equation

$$\Gamma = (C_s - C_i) \frac{t}{1000}, \qquad (3)$$

C_s and C_i being the concentrations in moles per liter in the surface layer and the interior of the solution, respectively, and t the thickness of the surface layer. The adsorption is expressed, therefore, in units of moles per sq. cm. of surface.

The chemical potential of the solute, μ, is defined by the equation

$$\mu = \mu_0 + RT \ln C_0 \cdot f, \qquad (4)$$

f being the activity coefficient and μ_0 a constant. Equation (2) follows from (1) by measuring the surface layer from a point such that

$$\Gamma_{H_2O} = 0 \qquad (5)$$

In more familiar terms (2) can be written as

$$\frac{d\gamma}{d(C_i f)} = -\Gamma \frac{RT}{C_i f} \qquad (6)$$

Equation (6) tells us that if the solute

accumulates at the surface, Γ positive, the surface tension will fall with rising concentration, as is the case with solutions of the fatty acids such as acetic, propionic, etc. On the other hand if Γ is negative as it will be when the solute is repelled from the surface toward the interior of the solution, equation (6) predicts that the surface tension will rise with rising concentration.

When equilibrium has been attained, we may write the law of mass action equation, letting A represent the solute

A(solution) $\rightleftarrows$ A(interfacial layer), (7)

or

$$\frac{C_s^A}{C_l^A} = K \qquad (8)$$

where K is the equilibrium constant of (7). From the principles of thermodynamics it also follows that

$$\frac{C_s^A}{C_l^A} = e^{\frac{-\Delta G^\circ}{RT}} \qquad (9)$$

where ΔG° is the free energy increase of (7) for the reactants and products in their standard states. (The surface standard state is thus seen to be different from the standard state in the interior of the liquid). Omitting the unnecessary superscript A, and combining (9) and (3) we see that

$$\Gamma = C_l \left(e^{\frac{-\Delta G^\circ}{RT}} - 1\right) \frac{t}{1000} \qquad (10)$$

If the work required to bring the solute to the surface is large, ΔG° positive and large, Γ will be negative and the surface tension will rise with rising concentration as it does in the case of sucrose solutions; conversely a negative value for ΔG means free energy evolved on adsorption, Γ will be positive and the surface tension should fall with rising concentration, as it does for most solutions of organic substances.

What may we expect the surface tension of ionic solutions to be? Consider an ion suspended in the vapor phase over a flat surface of water. It will be strongly attracted to the water because of the ion-dipole forces; in fact estimates show that the energy evolved when one mole of an ion passes from a vacuum to the interior of water is relatively enormous, from 50 to 100 kilocalories per gram ion. Most of the energy has probably been liberated by the time the ion has reached the surface layer, but there is still enough ion-dipole attraction to pull the ion toward the interior of the solution. For a point size ion, the attractive force is readily shown to be given by the equation

$$\frac{q^2}{4x^2D}\left[\frac{D-1}{D+1}\right] \qquad (11)$$

where q is the charge on the ion and x is the distance from the interface. Equation (11) tells us that only when x becomes infinite, does the force on the ion pulling it toward the interior become equal to zero; however, this can be shown to be an absurd conclusion because it means that all the ions in a solution would be repelled an infinite distance from the interface with a consequent infinite value to the slope of the surface tension concentration curve. Actually, ions are not repelled an infinite distance from the interface and the surface tension does not rise infinitely greatly as the concentration increases.

It is interesting to note that the Debye-Hückel theory of solutions provides us with the explanation of this apparent anomaly. As the solution becomes more concentrated, an ionic atmosphere is set up about each ion which in effect tends to screen the ion from the dipole attractions. The dipole attraction can be considered as a repulsion from the interface; the repulsion being between the ion in question and its "mirror image" in the vacuum at an equal distance above the water surface. The ionic atmosphere about the ion limits the thickness of the surface layer, the layer in which the ion concentration is depleted, to a distance of the same order of magnitude of the thickness of the ionic atmosphere, 1/K) where K is the well known parameter of the Debye equation.

Making use of the Boltzmann distribution law, of Equations (11) and (10) and of the general equations of the Debye theory, Onsager and Samaras[1] have been able to compute the course of the surface tension concentration curve for symmetrical strong electrolytes. For uni-univalent electrolytes the equation is

$$\frac{\gamma}{\gamma_0} = 1 + \frac{79.517}{D\,\gamma_0} C \log \frac{1.143 \times 10^{-13} (DT)^3}{C} \qquad (12)$$

As the logarithm term of Equation (12) is positive in the concentration range of

validity of the equation, the Onsager theory means a rise in the surface tension as the concentration increases. The first experimental measurements of surface tension in very dilute solutions were those of Jones and Ray[2] who found, most surprisingly, a *decrease* in surface tension as a function of the concentration up to a concentration of 0.001 N; above this concentration the surface tension rose in a manner suggestive of Equation (12). The significance of Jones and Ray's data in the light of the fundamental Gibbs equation was discussed at length by Dole[3] who developed a statistical theory of surface tension leading to the equation

$$\frac{\gamma}{\gamma_0} = 1 + \frac{RT}{\gamma_0}\,\frac{t \cdot C}{1000} - \frac{a}{\gamma_0}\,RT \ln \left[1 + \frac{C \cdot t/1000}{\frac{W/RT}{ae}}\right] \qquad (13)$$

where a is the number of surface locations per sq. cm. available for adsorption, and W is the adsorption potential. If the adsorption potential is high and positive, Equation (13) reduces to

$$\frac{\gamma}{\gamma_0} = 1 + \frac{RT}{\gamma_0} \cdot \frac{t \cdot C}{1000}, \qquad (14)$$

an equation which satisfactorily reproduces Jones and Ray's data for sucrose solutions. If W is negative, the logarithm term (at low concentrations) may far outweigh the second term of Equation (13) yielding the equation

$$\frac{\gamma}{\gamma_0} = -\frac{aRT}{\gamma_0} \ln \left[1 + \frac{C \cdot t/1000}{\frac{W/RT}{ae}}\right] \qquad (15)$$

valid for solutions of fatty acids.

By proper choice of the parameters a and W, Equation (13) can be fitted nicely to Jones and Ray's data, but the treatment seems unreasonable for the following reasons: First, the value for a, the number of adsorption positions per sq. cm., is only 1/100,000 the number of water molecules on the surface. There is no good reason to believe that the water surface would become saturated with ions with so few adsorbed on the surface. Second, there is no known mechanism to account for any attractive force.

Langmuir[4] has attempted to explain Jones and Ray's data on the basis of a water film held to the quartz surface of the capillarimeter by Φ-potential forces, the thickness of the film as a function of height being given by the equation

$$t = \left(\frac{kT}{\epsilon}\right)\left(\frac{\Pi D}{8\rho gh}\right)^{1/2} \qquad (16)$$

When salts are added to the pure water, the film disappears producing an effective increase in the radius of the capillary tube with a corresponding drop in the height of rise and an apparent fall in the surface tension. Langmuir's explanation was held to be doubtful by Dole and Swartout[5] who confirmed Jones and Ray's results using a differential twin-ring surface tensiometer. In this case there is, apparently, no vertical film of the type postulated by Langmuir.

However, we cannot yet assume that Jones and Ray's observations and the observations of Dole and Swartout represent true surface tension values. This is particularly true in as much as Long and coworkers[6] at Cornell University find that the surface tension of potassium chloride solutions as measured by a differential maximum-bubble pressure method follows along the Onsager and Samaras curve without the minimum of the Jones-Ray effect.

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6. Private communication of F. A. Long.

INVESTIGATIONS ON 3-HYDROXY-5-CHOLENIC ACID

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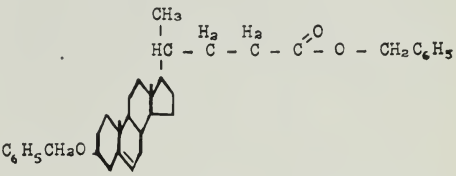
The ready availability of the bile acids makes them convenient starting materials for numerous conversions and syntheses. In the work reported in this paper, 3-hydroxy-5-cholenic acid resulting from the oxidation of cholesterol has been used. It is our purpose to study various means of building up natural compounds and of improving methods for the degradation of hydroxy bile acids to substances having possible androgenic, progestational and cortical hormone activity. 3-hydroxy-5-cholenic acid has a nuclear double bond and a secondary alcohol group that must be protected during the course of degradative or synthetic reactions on the aliphatic chain. It was thought that labile ethers, that is, ethers which could readily be removed when desired, would be the ideal means of protecting the hydroxyl group on C atom No. 3.

One of the first ethers chosen for this purpose was the trityl (triphenylmethyl) ether. The compounds were reported to be stable to alkaline reagents but easily hydrolyzed by mineral acids. This study has shown that the trityl group is replaced by the acetoxy group when the compounds are refluxed in glacial acetic acid or removed upon treatment with a Grignard reagent under even the mildest conditions.

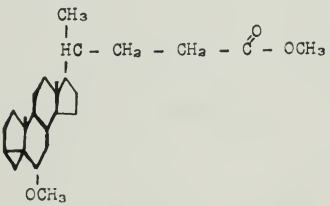
In this work, it was found convenient to use the methyl ester since the free bile acid is highly insoluble. The methyl ester was prepared in nearly quantitative yields (averaging above 90%) upon refluxing a solution of the acid in anhydrous methanol containing 3% HCl. The trityl ether was prepared in 85-88% yields when perfectly dry methyl 3-hydroxy-5-cholenate was heated on a steam cone for 8 hours with trityl chloride in absolutely anhydrous pyridine.

The direct benzylation of hydroxylated steriods has proven difficult. When methyl 3-hydroxy-5-cholenate was treated with benzyl chloride and pyridine under the rigorous anhydrous conditions employed in the tritylation, no benzyl ether was obtained. Likewise, the preparation of the benzyl ether by variations of Williamson's synthesis did not prove successful. The method employed by Stoll for the preparation of the benzyl ether of cholesterol was applied to methyl 3-hydroxy-5-cholenate. Attempts to prepare the p-toluene-sulfonate of 3-hydroxy-5-cholenic acid were unsuccessful. Therefore, the methyl ester was employed. When the methyl 3-p-toluenesulfonoxy-5-cholenate, prepared from the methyl ester, p-toluene sulfonyl chloride and pyridine at room temperature in 90-93% yields, was heated with benzyl alcohol on a steam cone for 5 hours, there were obtained 55-61% yields of



This compound exists in dimorphic forms melting 87-88° and 108.5-109.5°. The lower form can be converted to the higher melting form. This ether is stable to treatment with Grignard reagent and stable to 2 hours refluxing with glacial acetic acid.

In recent years the elucidation of the structure of the dextro or i-ethers by Stoll makes it seem that these compounds may prove useful in this work.



The 3-hydroxyl and the double bond are blocked eliminating the necessity of bromination and later debromination. The i-linkage can be broken up by refluxing with acetic acid, yielding the normal acetate which can then be saponified to liberate the hydroxyl group.

THE SYNTHESIS OF CANCEROGENIC HYDROCARBONS CLOSELY RELATED TO THE STEROIDS

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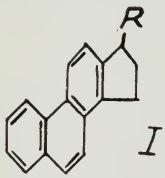
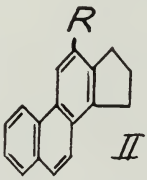
Studies of the carcinogenic activity of methylcholanthrene and cholanthrene have shown that they surpass in potency all other hydrocarbons previously investigated. From these results it might be inferred that cancerogenic hydrocarbons may arise in the living organism by the abnormal metabolism of steroids. To further elucidate this hypothesis, investigations have been planned to extend the studies of aromatic hydrocarbons related to the sterol nucleus.

At the present we are chiefly concerned in the synthesis of a number of derivatives of 3¹-substituted-1,2-cyclopentenophenanthrenes (I), 3-substituted (II), and 3,3′-disubstituted-1,2-cyclopentenophenanthrenes (III).



I



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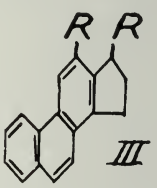


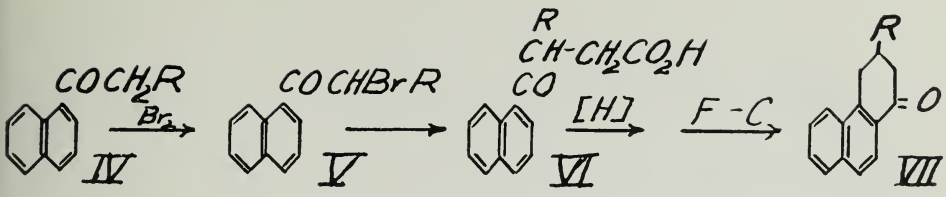
III

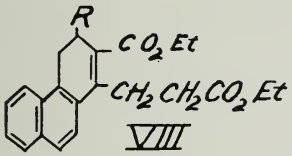
Previous syntheses of other molecules of this type have not been found practical, mainly because it is difficult to obtain the final product in sufficient quantity for complete biological assay. Therefore, it was necessary to find a good, general method which could be used for a whole series of compounds. An important intermediate for such a process is 3¹-keto-1, 2-cyclopentenophenanthrene.

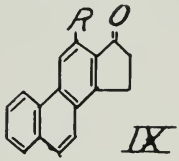
Catalytic reduction of phenanthrene, using copper-chromium oxide catalyst gives practically pure 9,10-dihydrophenanthrene.[1] This is readily acylated in the 2-position by means of an acid chloride with aluminum chloride.[2] In this way a β-bromopropionyl group was introduced into the 2-position. However, cyclyzation has been shown to go almost completely to the 3-position,[3] whereas the unhydrogenated phenanthrene nucleus, directs cyclyzation to the desired 1-position. All attempts to dehydrogenate the 2(ω-bromo) propionyl-9,10-dihydrophenanthrene or its ether derivatives lead to decomposition and polymerization, probably due to reactivity of β-substitution. Such an attack was, of necessity, finally abandoned.

At the present time two other methods of synthesis are being explored; which appear to be of a more promising nature. By the nitration of 9, 10-dihydrophenanthrene a good yield of the 2-nitro derivative can be obtained.[4] This is readily reduced to the amine either catalytically or with stannous chloride and hydrochloric acid. The resulting amine has been dehydrogenated with sulfur at 250-300° in good yield to give 2-amino-phenanthrene. An alternative method of preparation of this amine is thru the Beckmann rearrangement of the oxime of 2-acetylphenanthrene, which has been prepared in good yield by sulfur dehydrogenation of the 9, 10-dihydro derivative. The amine was then converted to the 2-bromophenanthrene by Bachman's[5] procedure. At the present time experiments are under way to prepare the 2(ω-bromo)-propionyl phenanthrene by condensation of β-bromo-propionyl chloride with either the magnesium or cadmium derivative of 2-bromophenanthrene. This product, when obtained, will be cyclysized with sulfuric acid to prepare the desired 3¹-keto-1, 2-cyclopentenophenanthrene. The keto compound can then be condensed with various Grignard reagents to give compounds of type I, above.

The second series of reactions now being studied lends itself to the preparation of compounds of type II and III. Here the starting material is α-naphthylnitrile, which is caused to condense with







aliphatic Grignard reagents to give compounds like IV. These are then treated with bromine to give α-bromo ketones (V), which are then condensed with sodio-malonic ester to give β-(1-naphthoyl)-β-alkyl propionic acids (VI). Subsequent Clemmensen reduction and ring closure gives 1-keto-3-alkyl-1,2,3,4-tetrahydrophenanthrenes[6] (VII). Condensation of VII with oxalic ester places a carbethoxy group in the 2 position and this is then followed by condensation of the ketone group with β-bromopropionic ester to give, after dehydration, the compound VIII. A Dieckmann ring closure, followed by decarboxylation should give a compound which could be readily dehydrogenated to the desired 3-alkyl-3[1]-keto-1,2-cyclopentenephenanthrene.

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ACYLALS[1]

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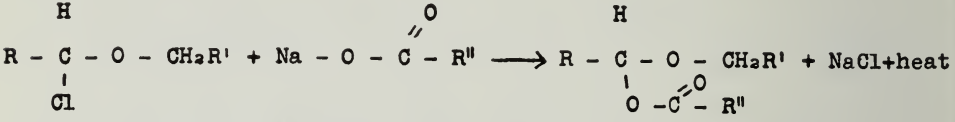
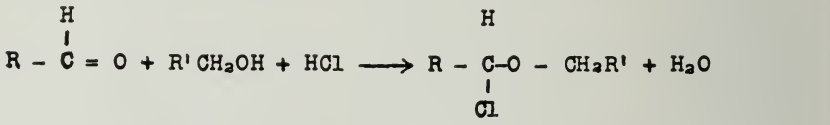
Hurd and Cantor[2] have suggested the name 'Acylal' for the product formed when the hydroxyls in the aldehydrol form of an aldehyde are replaced by ester groups. Therefore when one hydroxyl is replaced by an ester group and one by an alcohol group, the product may be called a mixed acetal-acylal.

When a sodium salt of an organic acid is shaken with a hemiacetal chloride, an exothermic reaction takes place whereby the acetal-acylal and sodium chloride are produced.[3] It is necessary to use an excess of the salt or rapid decomposition sets in, with the resultant production of a red tar-like material. The reaction appears to be general.



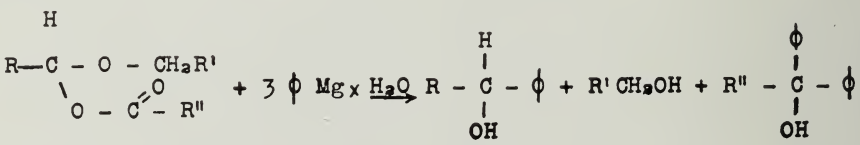
The hemiacetal chloride may be produced by the action of dry HCl gas on a cold, equimolecular mixture of alcohol and aldehyde. The procedure is a modification, similar to that due to Shoemaker and Boord,[4] of the Henry method.



The yields of acetal-acylal based upon crude hemiacetal chloride vary from forty to sixty percent of the theoretical, with an indication of better yields as based upon pure chloride. The densities of the compounds prepared vary from ninety-seven hundredths to eighty-nine hundredths, with increasing molecular weight. The molecular refractivities agree with theory. At twenty-five millimeters pressure the boiling points increase approximately ten degrees for each CH_2 unit added, regardless of its relative position in the molecule. If, pure, dry, and free from acid, the compounds are stable for some months.

The linkage in the compounds is apparently more of the acetal than the ester type. The compounds are somewhat resistant to alkali hydrolysis and are very responsive to acid hydrolysis.

At the present it seems quite likely that Grignard's reagent reacts with the compounds just as would be predicted, to produce a primary, a secondary, and a tertiary alcohol.



The compounds appear to produce the titanium chloride complexes analogous to those prepared by Pacsu[5] from similar structures in glycosides. The reaction takes place with great ease at room temperature, becoming violent unless a diluent is used. Approximately twenty new compounds have been prepared this year.

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[1] This work is a continuation of work begun at Northwestern University. The author is indebted to the Illinois Academy of Science for a Research Grant; and to Dr. Lauder of the Pet Milk Laboratories for the use of a Carbon-Hydrogen Combustion Apparatus.

[2] Hurd and Cantor, J. Am. Chem. Soc., *60*, 2678, footnote 8 (1938).

[3] Shoemaker and Boord, J. Am. Chem. Soc., *53*, 1505 (1931).

[4] A similar procedure was used by Farren, Fife, Clark and Garland, J. Am. Chem. Soc., *47*; 2421 (1925) for the preparation of formylals.

[5] Pacsu, Ber., *61*, 1508 (1928).

A STUDY OF THE OXIDATION OF TRIVALENT MOLYBDENUM

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That the oxidation of trivalent molybdenum may be carried out with considerable ease is evidenced by the fact that certain trivalent molybdenum compounds in solution are readily oxidized by atmospheric oxygen. Since trivalent molybdenum is oxidized from a valence of positive 3 to a valence of positive 6 and Mo^{IV} and Mo^{V} are known, it is to be expected that the oxidation proceeds in the following manner—

$$Mo^{III} \rightarrow Mo^{IV} \rightarrow Mo^{V} \rightarrow Mo^{VI}$$

In this work, the oxidation of molybdenum was followed very closely by means of potentiometric titrations, with bimetallic electrode pairs and an electron tube used in the circuit. Various oxidizing agents, addition agents, and acid concentrations were employed. The resulting data were plotted to give the titration curves for the oxidation of molybdenum.

The results, while not so complete and satisfactory as we had hoped they would be, have opened a field for further research. The work is being continued at Saint Louis University, where this project was begun. In the past, several articles on the oxidation of trivalent molybdenum have appeared. In most cases there was question of the oxidation $Mo^{IV} \rightarrow Mo^{V}$. However, Jakob and Michalewicz[1] concluded from their experiments that the potential of a Mo^{V} solution was not nearly so great as that of a Mo^{IV} solution and consequently when the $Mo^{III} \rightarrow Mo^{IV}$ oxidation appeared the $Mo^{IV} \rightarrow Mo^{V}$ oxidation would not appear, and when the $Mo^{IV} \rightarrow Mo^{V}$ oxidation appeared the $Mo^{III} \rightarrow Mo^{IV}$ oxidation would not.

These investigations led us to carry out oxidation experiments on reduced potassium molybdate solutions and on potassium chloromolybdate solutions under varying conditions, in an effort to explain further the oxidation steps. The measurement of amplified potential differences between bimetallic electrodes appeared to offer good results so we assembled the apparatus shown in fig. 1. This set-up was a modification of that of Goode[2]. Since it is not possible to obtain accurate results by means of potentiometric measurements when an extremely small amount of current is being drawn from the cell under investigation or when the cell resistance is abnormally high, a five-electrode tube was introduced into the ordinary potentiometric circuit. Our particular tube was an RCA 6K7.

Among the electrode pairs used were:
Platinum-Chromel
Platinum-Nickel
Platinum-Polarized platinum
Nickel-Chromel

The platinum-chromel pair gave by far the best results in the preliminary titrations and consequently was used throughout. Both the oxidizing and the reduced solutions were approximately N/10 but the strength of the acid mediums was much greater. The K_2MoO_4 solution was standardized by the accepted method[4]. This same technique was used throughout to reduce the molybdenum, but the Mo^{III} was run from the Jones reductor into a reaction vessel filled with CO_2. The CO_2 atmosphere was necessary to prevent oxidation by the air.

The oxidizing agents used were:
1. Ceric sulfate,
2. Potassium permanganate,
3. Ferric salts,
4. Potassium dichromate.

The various reaction mediums were:
1. H_2SO_4 (N, 0.4N, 0.6N)
2. HCl (2N, N, 0.4N)
3. Zimmermann-Reinhardt solution (20-25°C. and 60-70°C.)
4. H_3PO_4 (1.5 N.)

The addition reagents were:
1. $MnSO_4$
2. NH_4F
3. $MnSO_4$ and NH_4F
4. Ce $(SO_4)_2$

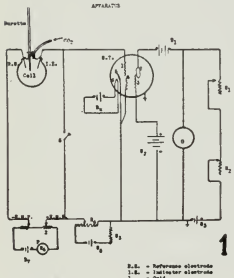
[1] Jakob and Michalewicz, Rozeniki Chem., *12*, 576-588 (1932).
[2] Goode, J. Am. Chem. Soc., *44*, 26 (1922).
[3] Willard and Fenwick, J. Am. Chem. Soc., *44*, 2516-2529 (1922).

Ceric sulfate has advantages over potassium permanganate as an oxidizing agent because it may be used in chloride solutions, is stable over long periods of time and has a potential close to that of the permanganate.

The curve shown in fig. 2 is that of Mo^{III} in H_2SO_4, titrated with Ce $(SO_4)_2$. The theoretical and actual end-points do not coincide, and there is no evidence of the oxidation $Mo^{IV} \longrightarrow Mo^{V}$. Using Mo^{III} in HCl, we obtained a curve in which the end-points again fell short of the theoretical end-point, and there was a break which corresponded to the $Mo^{IV} \longrightarrow Mo^{V}$ end-point, fig. 3. Addition agents did not improve these results. In general, the ceric sulfate titrations proved unsatisfactory. If a $Mo^{III} \longrightarrow Mo^{IV}$ oxidation occurred, there was no evidence of a $Mo^{IV} \longrightarrow Mo^{V}$ oxidation, and vice versa. An important contributing factor might be the inability to regulate the pH of the molybdenum solution when the oxidizing agent was added. The ceric sulfate itself is strongly acid, and the potentials of oxidants will vary with pH.

Titrating the Mo^{III} with $KMnO_4$ in H_2SO_4 solution did not produce the desired curve, so the potassium chloromolybdate solution was used in a Zimmermann-Reinhardt solution, fig. 4. While this titration proceeded rather smoothly, the $Mo^{IV} \longrightarrow Mo^{V}$ reaction was not indicated. When the titration of K_3MoCl_6 was repeated, this time in a sulfuric acid solution, a curve, fig. 5, was obtained, in which the break $Mo^{IV} \longrightarrow Mo^{V}$ was evident but not the $Mo^{III} \longrightarrow Mo^{IV}$ end-point. The titration of Mo^{III} in H_2SO_4 with $KMnO_4$ in the presence of $Ce(SO_4)_2$ gave a very strange curve, fig. 6. The drop in potential difference might indicate that the potential for $Mo^{IV} \longrightarrow Mo^{V}$ is lower than that for $Mo^{III} \longrightarrow Mo^{IV}$, as suggested by Jakob and Michalewicz. The titration of reduced K_2MoO_4 in Zimmermann-Reinhardt solution with $KMnO_4$ gave a very nice break in the curve for the oxidation $Mo^{IV} \longrightarrow Mo^{V}$, fig. 7.

Since at no time did we obtain a curve in which three steps in the oxidation were clearly indicated, it seemed advisable at this point to try oxidizing agents which would carry the oxidation only from Mo^{III} to Mo^{V}, as there was no question of the possibility of oxidation to Mo^{VI}. Ferric salts were chosen for this purpose. In the case of Mo^{III} in H_2SO_4 titrated with ferric sulfate, the oxidation proceeded nicely, giving us both the $Mo^{III} \longrightarrow Mo^{IV}$ and the $Mo^{IV} \longrightarrow Mo^{V}$ breaks in



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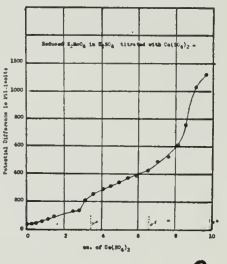

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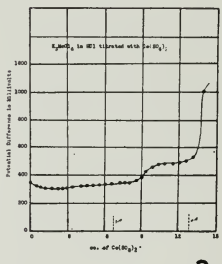

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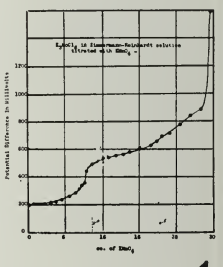

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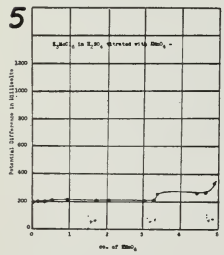

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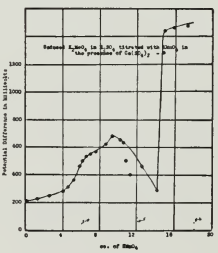

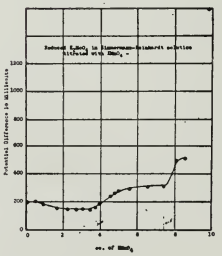

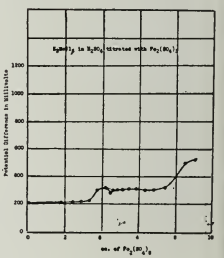

[4] Hillebrand and Lundell, Applied Inorganic Analysis, p. 250-252.

the curve, fig. 8, though, again, the theoretical and actual end-points were not the same.

In conclusion, it is evident from these data that the oxidation of molybdenum is not so simple as one might expect. It presents several complications which are not readily explainable. Why the oxidation from Mo^{III} to Mo^{IV} takes place in H_3PO_4 and not in HCl and H_2SO_4 solutions when titrated with $KMnO_4$, in the absence of addition reagents, is a matter for further investigation. One possible explanation is based on the assumption of the formation of stable complexes which are not readily attacked by $KMnO_4$.

Careful experiments have shown that the possibility of air oxidation in these titrations did not exist. However, in any one of the titrations when the total time of titration was longer than two hours, the amount of oxidizing agent required fell far below the theoretical amount.

The appearance of the $Mo^{IV} \longrightarrow Mo^{V}$ endpoint too early in the oxidation and the subsequent oxidation of Mo^{VI}, giving a complete oxidation long before it is to be expected, is not to be explained by any ordinary chemical means. There appears to be an oxidant other than $KMnO_4$ present, yet what it might be is not known. Spectrographic examination of the solution as the oxidation is being carried out might lead to a solution of the problem. Such analysis might show the presence of the complex ions which we feel may be present in the solutions.

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SEPARATION AND IDENTIFICATION OF SUGARS FROM MIXTURES

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In the attempt to develop methods for the separation and identification of sugars in mixtures several derivatives have been studied. The indirect methylation procedure (1938) is suitable for analytical separation by vacuum distillation of mixtures of mono-, di-, and trisaccharides but has not been found capable of development for further separation within these groups. Study of procedures involving crystallization of osazones, triphenylmethyl ethers, acetyl derivatives, and others has not proven satisfactory. Crystallization of the derivatives made from carbohydrate mixtures does not result in a smooth separation of the components. Trixenylmethyl ethers of xylose, glucose, galactose, maltose, lactose, trehalose were prepared. All are crystalline solids but these derivatives also were ineffective in helping to separate mixtures.

Satisfactory separations have been achieved by means of completely propionylated derivatives of sugars, prepared by action of propionic anhydride and pyridine on the sugar. Several of these propionates (maltose, gentiobiose, trehalose, sucrose, xylose, arabinose) are readily crystalline. All are distillable at low pressures (0.01 to 0.0001 mm.) in a special apparatus, even raffinose hendecapropionate. Since the propionyl group can be cleaved, after distillation, into appropriate fractions without rupture of the glycoside linkages, it is possible to convert non-crystalline propionates into other crystalline derivatives. Investigations of such mixtures as acid-hydrolysed corn sirup, hydrol, malt extract, etc., have already given fruitful results with this method. Gentiobiose has been isolated in ten percent yields as crystalline gentiobiose octapropionate from the disaccharide portion of hydrol. Maltose has been isolated similarly as crystalline maltose octapropionate from both non-diastatic malt extract and acid-hydrolyzed corn sirup. In addition, a convenient analysis of sugar mixtures has been developed, the essential features of which are propionylation and subsequent distillation of the sugar propionates at low pressures.

THE STRUCTURE OF MIXED HYDROGENATION CATALYSTS

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Benzene can be reduced to cyclohexane by hydrogen only in the presence of a catalyst. Ipatieff, Corson and Kurbatov[1] have shown that pure copper is ineffective as a catalyst, producing measurable reduction only at high temperatures and pressures. They have also shown that small amounts of nickel in the copper make it active as a catalyst. Where there is as little as 50 parts per million of nickel, in 90 seconds contact time at 225° C., they obtain 4% hydrogenation. Ipatieff, Corson and Kurbatov also found that these nickel-activated copper catalysts experienced an irreversible deactivation when they underwent prolonged heating at 400° C.

Nickel is ferromagnetic, but it is readily soluble in copper, and dilute solutions of nickel in copper are not ferromagnetic.[2] Thus, magnetic measurements can show whether a copper-nickel system consists of mixed crystals or of a solid solution of nickel in copper, or of both a solution and mixed crystals. Dr. P. W. Selwood and the writer have therefore made parallel measurements of ferromagnetism and catalytic activity in an effort to determine the nature of the change that reduced the activity of the catalyst.

The first samples of purified copper tested were strongly ferromagnetic owing to ten parts per million of iron. It was necessary further to purify this copper because the ferromagnetic effects due to any activating nickel would have been obscured by the iron. Copper containing less than one part per million of iron was finally obtained by electrolysis. This copper was made by electrolysis from c.p. copper sulfate. The deposit was dissolved in redistilled nitric acid and again electrolyzed. Copper purified in this way was found to be inactive in the hydrogenation of benzene, confirming the results of Ipatieff and Corson, and contradicting those of Pease and Purdum[3], who claimed that copper prepared from c.p. copper oxide was an active hydrogenation catalyst. This purified copper was activated with 1% of nickel. Nickel nitrate solution was stirred into a slurry of copper hydroxide. It was dried, decomposed by heating, and reduced by hydrogen at 200° C. This catalyst effected 60% reduction of benzene in 30 seconds at 175°. This active catalyst was strongly ferromagnetic. The ferromagnetism of the catalyst shows that the nickel is not in solution in the copper. The catalyst must consist of mixed crystals of copper and nickel.

The catalyst was then heated at 350° for two hours, and again tested for catalytic activity and ferromagnetism. It was found to be only one third catalytically effective as before, and only one third as ferromagnetic.

It may be concluded from these results that the catalyst loses its activity because it forms a solid solution of nickel and copper. That is, that thermal deactivation consists of a process of diffusion of the nickel into the copper.

The catalytic activity was measured by an apparatus designed and built by Ipatieff and Corson. Hydrogen gas was purified by passing it successively over (1) copper gauze at 550°C. in a quartz tube; (2) through lead acetate solution; (3) potassium hydroxide; and (4) drying tubes. It was then passed into benzene at 25°C. in a thermostat, and finally over the catalyst. The gas was then passed through traps cooled in dry ice to catch the benzene and cyclohexane.

The magnetic susceptibility was measured by the Gouy method.[4] The sample tube was hung from one pan of a micro balance above an electromagnet, so suspended that the middle partition was in the center of the magnetic field. One end of the tube was evacuated and the catalyst packed into the other end. The tube was weighed with no magnetic field. Then the magnet was turned on and the tube weighed again. The apparent change in weight was proportional to the magnetic susceptibility.

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THE HISTORY OF CHEMISTRY AS APPLIED TO PHOTOGRAPHY

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Peoria, Illinois

The history of photography and the history of chemistry are, naturally, closely parallel. The relationship is much closer than between physics and photography. With the exception of the invention of a new glass or two, the devising of a few new lens combinations, and more recently, the introduction of new polarizing screens and a glass-coating, reflection-reducing technique (in themselves, partly chemical), most of the advances in the art-science of photography have been made as almost direct offshoots of the discoveries of the chemists.

In fact, the alacrity with which these discoveries have been incorporated into the body of photographic theory and usage has been little short of amazing. Iodine, isolated in 1811 was used by Daguerre some time before 1835 and bromine discovered in 1828 was put to photographic use in 1840 by Goddard to increase the sensitivity of Daguerreotype plates. In 1819 Herschel pointed out the action of sodium thiosulfate upon silver salts and in 1839 he urged Talbot to use the same salt for fixing photographic images. That salt is still by far the most commonly used fixing agent today. For this contribution it would seem that Herschel deserves a much more prominent place in the annals of photography than he is usually allotted.

To fully appreciate the importance of chemical discoveries in the history of photography, let us list what would seem the major advances made in the latter field and note how many of them are an outgrowth of chemical advances.

First, there was the noting of the effect of light and the differential effect of light of different colors upon silver compounds by the Swedish chemist, Scheele. Schulte, Wedgewood, Davy and others made use of these facts in securing printed silhouettes. These they did not know how to fix. This major contribution (though it was on entirely different chemicals) was made by Niepce. Herschel's contribution, already mentioned, made fixation possible on silver salts which were and have always been the most commonly used metallic constituents of the light sensitive materials used in photography. Then came the profound and revoluntionary contribution of Daguerre; namely, the concept of a latent image capable of later intensification or development as it is now called. Prior to that idea, the notion of obtaining a positive image directly in the camera had obsessed the minds of investigators to the point where no other solution of the difficulties encountered seemed possible.

Thus the most fundamental discoveries were made; a light sensitive medium, development, and fixation. Later came many contributions. Important among these were the negative-positive technique of Talbot's calotype process making possible images that were not mirror-images and also the possibility of many positive prints from one negative; a long series of improvements in the sensitivity of photographic emulsions, both as to speed and to orthochromatics, outstanding of which were the contributions of Schönbein (discovery of collodion) and Scott-Archer (use of collodion in the form in which it is still used photographically), Vogel's work on sensitizing films to green light (as a natural aftermath to the discoveries of Hofmann and Perkin), Rev. Goodwin's perfection of the gelatino-bromide film base (more commonly credited to Eastman), and the publication of the work of the Lumière's on the chemical properties which make organic substances photographic developers. Kekule's prior contributions concerning the benzene ring structure (the basis for nearly all the photographic reducing agents) must not be overlooked.

The whole story of reduction, intensification, sensitization, toning, color processes (exception must be made here to the pioneering work of the physicist Clerk Maxwell), image reversal, and the use of magnesium for lighting is the story of chemical progress, out of phase with photographic history by only a few years.

To paraphrase a political adage, one might say "As chemistry goes, so goes photography."

CATION EXCHANGE IN A CARBONACEOUS ION EXCHANGER

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Northwestern University, Evanston, Illinois

Introduction.—The distribution of a pair of cations between a solution and a solid ion exchanging body such as a zeolite has been studied by many investigators and for different materials. Generally speaking, true equilibrium has not been reached in these studies, for the distribution has been different according to the direction from which it was approached, but the rather definite pseudo-equilibrium can be represented empirically by the equation

$$\left(\frac{C_1}{C_2}\right)_{\text{solid}} = K \cdot \left(\frac{C_1}{C_2}\right)^{p}_{\text{solution}} \quad \ldots\ldots (1)$$

where K and p are constants, p being less than one (Rothmund and Kornfeld, Z. Anorg., *103*, 129, 1918).

In one or two cases (e.g., Moller, Koll. Beih., *46*, 1, 1937), true equilibrium was reached, and, at the same time, the mass action law was obeyed, p in the above equation being one. This raises the question whether p will not always be unity for a true equilibrium. To answer this question was one of the aims of the present investigation.

A new type of exchanger made from bituminous coal by treatment with sulfuric acid or sulfur trioxide has come into use in recent years. Such a material is "Zeo-Karb", manufactured by the Permutit Company. This was chosen for investigation because the great speed of its ion exchange reactions would favor approach to equilibrium and also because of its technical importance and the fact that exchanges involving the hydrogen ion can be performed with it. The exchanges first studied were calcium-sodium and sodium-hydrogen.

Experimental Method.—The Zeo-Karb was first ground to 40-80 mesh. Portions were saturated with calcium, sodium, and hydrogen ions by passing solutions of calcium and sodium chlorides and of hydrochloric acid, and were then washed and air-dried. Weighed samples were shaken with 50-200 cc portions of solutions containing the chloride of the other cation which was to participate in the exchange. Control experiments showed that no observable change occurred between 6 and 72 hours of shaking, so that after 12 hours the supernatant solution was withdrawn and analyzed.

It was necessary to know the saturation capacity or "ultimate exchange" of the Zeo-Karb. This was found for the calcium Zeo-Karb by digestion with concentrated sulfuric acid and analysis of the resulting solution, also by leaching out the calcium by dilute acid. The sodium Zeo-Karb was first saturated with hydrogen ions, and these displaced by potassium ions and titrated.

It was also desirable to know whether the extent of swelling of the material in water would change with ionic exchange, since Graf (Koll. Beih., *46*, 229, 1937) showed that the swelling of casein had a marked effect on the ion exchange. Tests showed that the volume of the Zeo-Karb varied by one to two per cent at the most during the ion exchanges studied.

RESULTS

(a) *The Calcium-Sodium Exchange.*—The data obtained by agitating pure sodium Zeo-Karb with calcium chloride solution, and pure calcium Zeo-Karb with sodium chloride solution, are given in fig.1. The data are plotted according to the equation

$$\left(\frac{(Ca^{++})}{(Na^{+})^2}\right)_{\text{Solid}} = K \cdot \left(\frac{A_{Ca^{++}}}{A^2_{Na^{+}}}\right)^{p}_{\text{solution}}, \quad \ldots\ldots (2)$$

A being the activity calculated by the simple Debye-Hückel theory.

The index p for exchanges in the N/25 solution was 0.82-0.84. The distance apart of the two curves, however, shows that true equilibrium was not attained,

* Former Research Chemist, The Permutit Company.

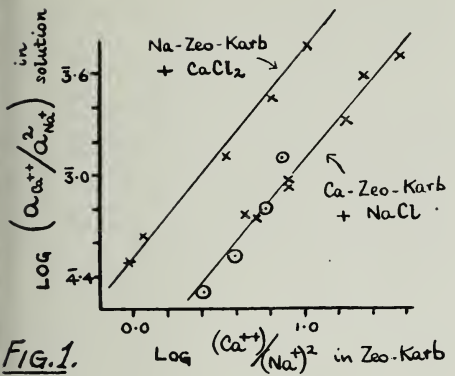

FIG. 1.

Fig. 1.—*Units*: Activities in solution milliequivalents per liter. Concentrations in Zeo-Karb, milliequivalents per gram air dried weight.

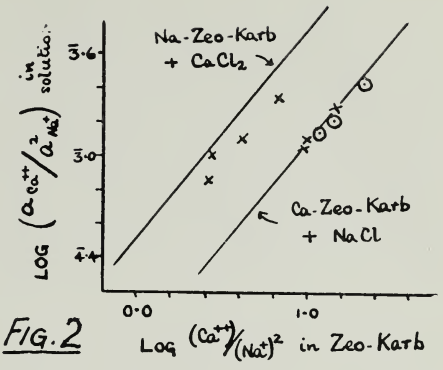

FIG. 2

Fig. 1.—*Units*: Activities in solution milliequivalents per liter. Concentrations in Zeo-Karb, milliequivalents per gram air dried weight.

even though ample time had been allowed in the experiments for the exchange to reach a steady state. To allow a better chance for equilibrium to be approached, some tests were made where samples of Zeo-Karb which had been used in the main series of tests, and so already contained some of the second cation, were shaken with fresh quantities of salt solutions. The points so obtained are shown by crosses in fig. 2. The data obtained starting with sodium Zeo-Karb showed some inclination to approach the mean of the two curves, but the data for calcium Zeo-Karb stuck closely to the original Ca-Zeo-Karb and NaCl curve.

The calcium and sodium Zeo-Karb stocks had been prepared a year previous to making these tests, and might have acquired a permanent set so that they were in reality two different exchange materials. Therefore, a quantity of sodium Zeo-Karb stock was saturated with calcium ions and three tests were immediately made by shaking samples of this material with N/25 sodium chloride solution. The points obtained are shown as circles in fig. 2 and lie very close to the regular Ca-Zeo-Karb+NaCl curve. The conclusion is that the exchange characteristics of Zeo-Karb are conditioned by the ion with which the material was last saturated and do not change until the material is saturated or nearly saturated with another ion. A similar conclusion was reached by Renold (Koll. Beih., *43*, 1, 1935) from his work on synthetic aluminosilicates.

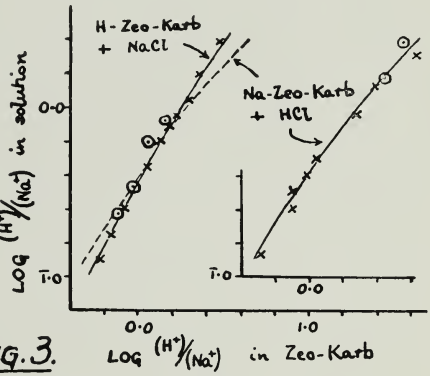

FIG. 3.

The effect of concentration of the solution is seen from fig. 1, the circles referring to N/10 NaCl + Ca-Zeo-Karb. For a given ratio Ca:Na in the exchanger, the simple Ca:Na ratio in the solution is greater in the more concentrated solution, but by plotting activities according to the equation given, a relation is obtained which is independent of the total salt concentration.

(b) *The Sodium-Hydrogen Exchange.*—These results are given in fig. 3. The simple ionic concentration ratios were plotted, these being assumed equal to the acitvity ratios in solution. The curves for Na-Zeo-Karb + HCl and H-Zeo-Karb + NaCl almost coincide, showing a close approach to equilibrium. The index p in Equation 1 is about 0.6, which shows that the mass action law ($p = 1$) is *not* necessarily obeyed for a true equilibrium.

These graphs are, however, definitely not linear. It may easily be that Equation 1 is not valid for exchanges involving the hydrogen ion; this will be seen more clearly when data for the sodium-potassium exchange in Zeo-Karb are available for comparison.

The effect of total concentration is seen from fig. 3; the crosses refer to N/25 solution, the circles to N/10. As was expected for a pair of ions of the same valency, concentration has no effect on the distribution.

Acknowledgments

The work described developed out of researches carried on in the laboratories of The Permutit Company, Birmingham, New Jersey. The writer is indebted to The Permutit Company for the gift of Zeo-Karb and also for permission to publish these results.

Papers in Geography

Extract From the Report of the Section Chairman

The Evanston program carried 11 papers, all of which are herewith published.

The chairman for the Urbana meeting in 1942 as elected by the 28 attending was: Joseph Van Riper, Southern Illinois Normal University, Carbondale.

(Signed) Arthur B. Cozzens, *Chairman*

U. S. AIRWAY WEATHER STATION, CARBONDALE, ILLINOIS

Erselia M. and Thomas F. Barton
Southern Illinois Normal University, Carbondale, Illinois

More than ever before does the present World War show the importance and need for a thorough knowledge and understanding of weather and climatic conditions. For a people to prosper and defend itself adequately today such a knowledge is essential. Although weather data are commonly used when planting crops; buying and selling goods; planning road itineraries; or properly heating a house, it took the present war to make all men really weather conscious. During the last decade through commercial and military aviation the "weather eye" public has increased with an accelerated tempo.

Wishing to help with this movement to understand weather, the writers will describe the operation of an Airway Weather Station, and show how such a station can contribute to the educational curriculum.

In April, 1940, a second class Airway Weather Station was established on the Southern Illinois Normal University campus at Carbondale under the supervision of the Geography Department. The Federal Government provided all the technical equipment and supplies while the Geography Department provided office facilities and personnel.

The station contains the following technical equipment: Mercurial barometer, barograph, anemometer and wind vane, wind velocity and direction indicator, maximum and minimum thermometers and holder, whirling apparatus for wet and dry bulb psychrometer, rain and snow gauge, weather shelter.

Before being permitted to take authoritative readings, the three observers selected to take readings had to pass a Civil Service examination and secure Certificates of Authority to take Airway Weather Observations. Two of these observers, Harry Chester and James Chandler are college geography majors, and the third, Thomas F. Barton, Chairman of the Geography and Geology Department, is sponsor of the station.

Every day, between 6:10 and 6:30 A. M. and P. M. and between 12:10 and 12:30 A. M. and P. M., weather observations are taken. Weather recordings are made, computed, coded, and telegraphed to Chicago in twenty minutes. From Chicago this information is made available by teletype for commercial and military airports throughout the United States.

For example at 12:29 P. M. on April 19, 1941 the following message was wired to Chicago in code:

43387 19403 08172 65502 66065 69217 67

The first three digits of the first group of numbers describes the location of the station as to latitude and longitude. The fourth number of the primary group shows that the sky was completely covered with clouds and the last number indicates that at the time of reading visibility was between six and twelve miles. In the same way the numbers in each of the following groups give a quantitative description of weather.

The following weather phenomena are observed, computed, and recorded at each six-hour reading:

1. Total amount of cloud
2. Visibility in miles or feet
3. Wind direction and velocity
4. Present weather (of which there are ninety-nine kinds)
5. Station and sea level pressure
6. Dry-bulb and wet-bulb temperatures
7. Dew point
8. Three hour station pressure change and pressure characteristic
9. Kinds of low, middle and high clouds
10. Cloud height and direction of cloud movement
11. Character, time and amount of precipitation or character and time of thunderstorm
12. Maximum and minimum temperatures.

At the end of each month four copies of the monthly weather summary are made. Of these, three are sent to Kansas City where one is filed, one is sent to the

Weather Bureau at Springfield, Illinois, and the other goes to the Weather Bureau in Washington, D. C. The fourth copy is filed for reference work in the Geography Department.

Use of Weather Data.—One of the most important elements of Physical Geography is weather. Almost everybody is interested in local weather conditions but most people believe with Mark Twain that nothing is ever done about the weather. However, at Southern the Geography staff members who use Finch and Trewartha's *Elements of Geography* as a text in the introductory course, are attempting to teach students how to describe, interpret and predict weather conditions. Consequently, by having weather readings every six hours, the Geography instructors have accurate local data to use in classroom presentations.

This information is also used in the college geography laboratory classes having as their objective the understanding of weather and weather instruments. Most students are interested in timely and local statistics that explain the weather drama as it is enacted. From local description and interpretation one can go on to broader generalizations on the subject. From the standpoint of weather instruments, in the laboratory or workshop there are various weather instruments similar to those used in the station but differing somewhat in that they may be demonstrated from time to time.

Although not completely equipped at present the workshop contains the following instruments: mercurial and aneroid barometers, barograph, thermograph, hygrograph, humidaguide, hand sling psychrometer, maximum and minimum thermometers, an indoor-outdoor thermometer, and a rain and snow gauge. Students are taught the mechanism and uses of each instrument as well as how to read it. After an understanding of the instruments is achieved practical functional problems connected with weather elements are studied.

The use of these daily reports not only stimulates interest in weather, but actual observation of the station itself also awakens in pupils a keen interest in weather problems in general. The station has been shown to rural, intermediate grade, junior and senior high school pupils, to college students and to "in-service" teachers. From past experience, one can safely say that most of these students, regardless of grade level, were impressed and stimulated by these trips. In fact, many have set up their own inexpensive weather stations, either at home or at school.[1]

[1] Barton, T. F., "Why Not Build an Inexpensive Weather Station at Your School?" *Illinois Education*, *Ibid.* "Establishing an Inexpensive Weather Station: An Abstract," *Journal of Geography.*

AGRICULTURAL LANDSCAPES OF THE SUDBURY AREA, ONTARIO[1]

THOMAS F. BARTON
Southern Illinois Normal University, Carbondale, Illinois

Two distinct agricultural landscapes are developing within a few miles of each other in the Sudbury Area of Ontario, Canada, namely the "Agricultural Landscape of the Sudbury Pocket"[2] and the "Disseminated Agricultural Landscape Among the Ice-scoured Hills." These landscapes represent the two types of agriculture most prevalent on the Laurentian Highlands.

As it is true elsewhere in the Canadian Shield the best agricultural land of the Sudbury Area is confined to pockets. The Sudbury pocket is the middle one of "five areas more or less fit for settlement"[3] which are located in the portion of the Shield contiguous to the north shore of Lake Huron and Lake Superior. These pocket areas, as briefly described by Lower,[4] are from east to west: North Bay, Lake Nipissing, Sudbury, Sault Ste. Marie, and Fort Williams and Port Arthur.

The Disseminated Agricultural Landscape Among the Ice-scoured Hills resulted from the scattered and often persistent attempts of pioneers to hew farms among the glaciated hills of the Canadian Shield.

Although both of these agricultural landscapes developed under the same climate and produce crops for the saxicultural markets, differences in landforms, soil, and stage of development result in a different cultural landscape. Because of physical and cultural dissimilarities these two landscapes will be treated separately, although they do have many characteristics in common.

AGRICULTURAL LANDSCAPE OF THE SUDBURY POCKET

By driving seven miles northwest of Sudbury through a cut-over forest landscape, one enters an agricultural pocket by means of a water gap at Azilda (fig. 1). Here agricultural features, patterns and associations are superimposed upon a lacustrine plain of an abandoned glacial lake. This pocket, about twenty-three miles long and eight wide, is roughly boat-shaped with a prow at the west end of Vermilion Lake and the stern about five miles southwest of Wanopetei Lake. This area represents roughly an old glacial lake bed in the central portion of the Sudbury basin.

All of the land in the Sudbury pocket is not in farms, and rather large tracts have never been cultivated. Near the center of the lake bed are several sandstone ridges, remnants of former anticlines. Parts of these ridges have never been cultivated and account for much of the wooded land in the pocket. Most of the few farms located on the sandstone ridges have been abandoned.

The islands of cultivated land in the northern part of this boat-shaped area are separated from the larger area of farm land to the south by cut-over forests. Clearing and settling have not been rapid in the northern part of the plain because the soil is too sandy, gravelly, and often too wet for agriculture. Moreover, in spite of a long period of development, there still exists near the center of the pocket islands of timber surrounded by cultivated land. These timber islands occupy the gravelly, rocky, poorly drained or most inaccessible parts. The reader should keep in mind, however, that this agricultural pocket contains more cultivated land and more farms than all the rest of the Sudbury Area.

On this plain the roads, although following a rectangular pattern, are not laid out in perfect square mile intervals.

[1] For practical purposes at present the writer uses the term "The Sudbury Area" when writing of that portion of Ontario included on the Sudbury Topogaphical Sheet which is published by the Department of Interior. The area is forty-eight miles long from east to west; thirty-four miles wide, and is named after its largest city, Sudbury.

Information in this paper is based upon six weeks' field work in the summer of 1939 and library research.

[2] The term *pocket* is used to designate small areas of arable land located in depressions in the Laurentian Upland.

[3] Lower, A. R., "Settlement and the Forest Frontier in Eastern Canada," *Canadian Frontiers of Settlement*, Vol. IX, p. 12.

[4] *Ibid.*

Often two parallel east-west roads one mile apart will only be connected by north-south roads at intervals of two miles. The dispersed rural dwellings are usually found along the principal east-west roads but seldom on the north-south connecting roads (fig. 2).

The rural homes are concentrated along the main gravel roads with usually six to twelve houses to a mile. There are about five hundred families with an average of four or five to a family in the pocket.[5] The farms have the elongated strip shape of typical French Canadian land holdings. Often there are two houses in the same farmyard—the older dwelling may be occupied by the parents and the newer one by a son.

The farms are small, usually comprising sixty to eighty acres with many small fields devoted to potatoes, barley, truck crops, and hay. For example Rodolphe Paquette owns an eighty-acre farm on the southeast corner of the crossroads at Boninville. During the summer of 1939 he had thirty acres of potatoes, ten acres of hay, eight acres of oats, four and a half of truck garden, and the rest of the farm was in yards and pasture. Instead of having each cultivated crop in one field, the crops were planted in several small fields giving a patchwork field pattern. However, on most farms mixed hay occupies more of the land than any other crop, and on many farms it occupies more land than all the other crops combined. Farms, pastures and farmyards are usually enclosed with wire, rails, or poles, but cultivated fields within a farm are often not enclosed.

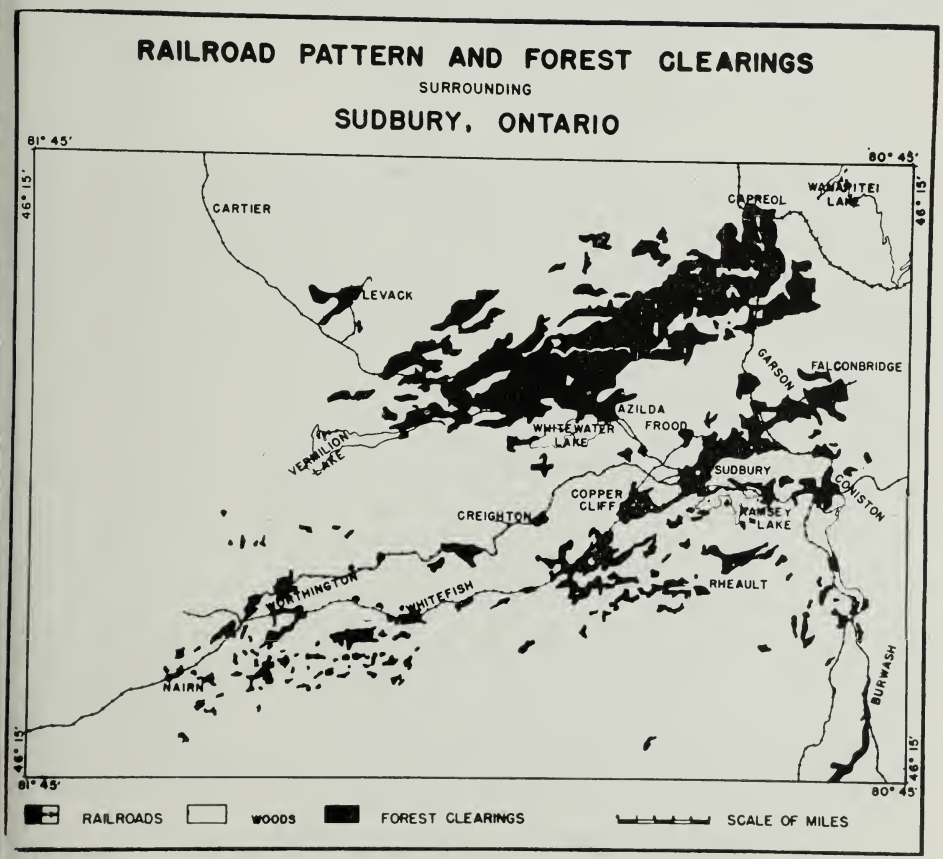

Fig. 1.

[5] Data given by Romeo Leroux, agricultural representative of the Sudbury District, in an interview on August 8, 1939.

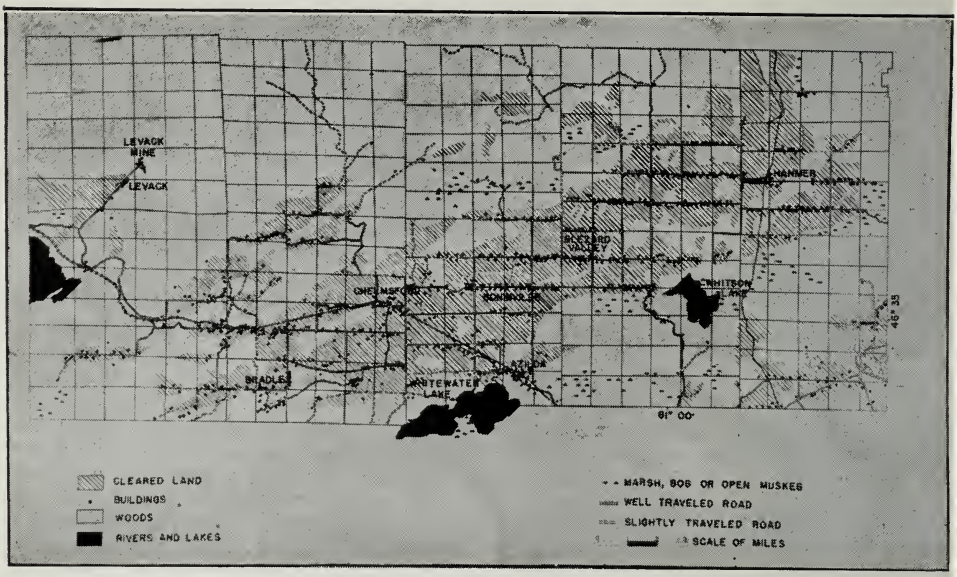

Fig. 2.—Agglomerated Agricultural Settlement in Sudbury Pocket, Sudbury Area, Ontario.

A representative farmyard contains a house, garage, combined barn and crib, potato cellar, and woodpile (fig. 3). Houses are usually of the one or two-story square wooden type but log houses are not uncommon. Most of the once white houses are badly in need of paint. The grain crib and barn are usually combined in order to facilitate the feeding of livestock during the long cold winters and deep snows. This structure is either large and well made, or small, crude and made of rough lumber. If large, it indicates the farmer is in the commercial dairy business; if small, he only keeps a cow or two for his own domestic use. Protruding through the roof of the larger barns are the windmills. The water tank and part of the windmill machinery are thus protected from the deep snows and freezing temperatures.

Going through the country in early August one sees checkerboard fields of green and yellow. Late potatoes, peas, hayland, pastureland, and some corn produce various shades of green; while the yellow is due to the ripening fields of oats, barley, and fall rye. In December the fields are covered with a deep blanket of snow (The city of Sudbury receives an average of 63.2 inches of snowfall a year).

The variety of crops grown and the production per acre are closely related to climate, soil, landforms, markets, and transportation facilities.

Climate imposes harsh limits upon agriculture. The late springs, cold and wet, retard the planting season. June with 2.91 inches receives more rainfall than July with 2.54 inches.[6] Not only do heavy rains interfere with the planting in spring, but sometimes they come during the harvest season spoiling hay, causing oats to sprout in the shock and potatoes to rot in the ground. August with 2.85 inches of rainfall is one of the wettest months of the year, and September is the wettest month with 3.1 inches. The three principal growing months of June, July, and August receive an average of 8.3 inches of rainfall. However the rainfall is not dependable. Droughts are frequent and may come any time during the summer. June and July are the only months having a monthly average of normal daily mean temperatures above fifty degrees.[7]

The average growing season is ninety days or less. Moreover, many nights have very low temperature although frosts do not occur. Often frosts occur late in spring or early in fall with a possibility of frost any time during the

[6] Conner, A. J., "Meteorological Tables" reprinted from the Canada Year Book, 1931, p. 21.
[7] *Ibid.*, pp. 12-13.

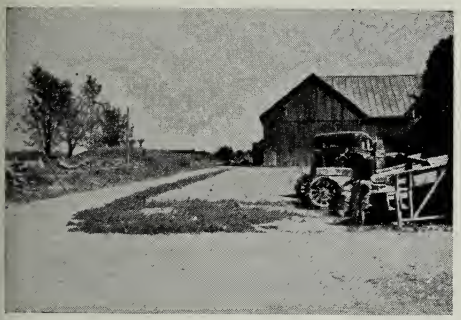

Fig. 3.—View of farmstead in August. Notice dwindling wood piles, and entrances and ventilators to earthen potato cellars. Jacked up hind wheel of old-modeled car furnishes power for potato grader.

year. June, July, August, and September are the only months free of snowfall. Thus, it is not surprising to find crops that are adapted to a high latitude interior continental climate. Buckwheat, barley, and potatoes are suited to a short season, and oats, hay and pasture to cool temperatures.

Soil presents both physical and chemical handicaps. Much of it is too sandy, gravelly and rocky. The better drained loam soils are underlain with fine sand to a depth of six to twelve feet.[8] However, where clays predominate, the soil retains its moisture long after the heavy blanket of snow has disappeared. Thus an already dangerously short growing season is further handicapped by wet soils, delaying the planting period. Typical of the podsols these soils are high in humus content. Being friable and well drained, they make good potato land if properly fertilized. The soils are high in potassium and magnesium, but low in lime and nitrogen.[9] Crop yields soon decline where cultivation is carried on year after year without adequate fertilization. Clover is grown to restore vegetable matter and nitrogen to the soils. Limestone and nitrogen fertilizers are shipped into the area from Niagara Falls.[10]

Because of the irregularity of the land surface in the Sudbury pocket, much of the total area is unfit for cultivation. In

Fig. 4.—Holstein herd near Blezard Valley. Looking north, note large barn, silo, wooded tree line, and profile of the sandstone hills which occupy the center of the Sudbury pocket.

[8] Interview with Romeo Leroux on August 8, 1939.
[9] *Ibid.*
[10] Interview with Romeo Leroux on August 8, 1939.

the southeastern portion the lake plain gives way to moraines and small pitted outwash plains. Sand and gravel terraces are located in the southwestern part of the pocket along the margin of the lacustrine plain. The flood plain of the Vermilion River with its numerous oxbow lakes is too wet for cultivation. The sandstone ridges near the center of the pocket, although partially cleared and farmed in the past, have now been mostly abandoned. The undesirable landforms and associated soils prevent the agricultural pocket from developing a more perfect boat-shaped area.

In addition to the physical factors of climate, soil and landforms, markets also influence agricultural development. The demand for fresh milk and vegetables created by the mining towns and Sudbury help explain why dairying and truck farming predominate in the area. Milk, potatoes, and baled hay are the principal cash products.

Potatoes lead the list as a cash crop with about a quarter of a million bushels produced annually on about two thousand acres.[11] The early crop is harvested the first part of August and the second crop about the middle of September. In 1939 potatoes were selling for $1.25 to $1.50 per bag in Sudbury where the bulk of the crop is consumed.[12] In addition to climatic handicaps, the potato crop, if not treated in time may sometimes be damaged by the potato leaf hopper or blight.

In addition to potatoes a large variety of fresh vegetables are grown for the mining population. The importance of truck marketing is reflected in the urban landscape. Covered markets are maintained in Sudbury and Copper Cliff. Buggies, light wagons, and antiquated automobiles loaded with vegetables are common daily sights in the town and city streets.

The second most important cash product is milk. It is the dairy cow that changes the bulky grain, hay and grass into milk which can be more readily marketed. (Fig. 4.) Farmers from the northern and northwestern part of the pocket move milk into Sudbury by truck. Fresh milk does not reach Sudbury from the central part of this area around Boninville for two reasons. Here the potato is the chief product. Moreover what milk is produced for sale goes to a small cheese factory at the Boninville crossroads. This factory gets most of its milk within a five mile radius. About three to four large Canadian cheddar cheeses are made daily throughout the year with a maximum production in spring. The minimum production is in August when only about a dozen farmers bring in milk once a day.[13]

Experimentation with corn and silos is associated with the dairy industry. During the summer of 1939 a new quick maturing variety of corn known as Dorinny was introduced.[14] Planting was delayed by rains and the experiment could not be called a success. The area will likely continue to be used for experimentation with quick maturing varieties of corn. Silage would undoubtedly be of great aid to dairying if corn production were feasible.

In 1939 there were about 4,000 head of dairy cattle in this agricultural pocket. Most of the cows are Ayrshires. A cattle carload of Ayrshire cows was shipped in from Glengairy county in eastern Ontario in the fall of 1939 which would indicate that the dairy business continues to expand.[15]

In spite of the expansion of dairying within the Sudbury pocket and the dispersed agricultural settlements in the Sudbury Area, milk production is still insufficient to meet the demand created by the mining population. Consequently Sudbury dairies send their trucks as far as Bruce Mines, 160 miles west of Sudbury, and as far as Sturgeon Falls,[16] 60 miles east of Sudbury, for milk and cream.

Not only does the Sudbury Area depend upon outside sources for milk but also for all food supplies. No phase of agriculture has developed to the extent where it meets the needs of the Sudbury Area. The growing mining population produces only a negligible part of its own food.

[11] *Ibid.*
[12] The Sudbury Star, August 18, 1939.
[13] Interview with Arthur Legault, manager of the factory, August 18, 1939.
[14] Sudbury Star, August 18, 1939, p. 11.
[15] Sudbury Star, August 18, 1939.
[16] Interview with O. L. Bingham of the Palm Dairy on August 23, 1939.

In spite of excellent markets nearby and improved roads connecting this agricultural pocket with the agglomerations of population in the Sudbury Area, most of the farms and farmsteads do not look prosperous and give ample evidence that the owners are having a hard time to eke out a living. In fact, there are few farms which have always been economically independent. The present development and economic status of many farms is understood when one realizes that money made in mining, lumbering, or trapping has been invested in these farms. It is a common, practice for one or more members of a family to work in the mines for a few years. This is especially true when crops fail or the mines are booming and wages high. It is also true that what prosperity exists is primarily explained by the markets the mining industry has provided.

Disseminated Agricultural Landscape Among the Ice-scoured Hills

Two primary districts of dispersed agricultural settlement in the Sudbury Area create a distinctive landscape. The writer has named this landscape the Disseminated Agricultural Landscape among the Ice-scoured Hills. Of the two districts in this landscape, one is the Kelley Lake-Long Lake district, east of the Whitefish Lake Indian Reserve No. 6 and just south of Sudbury and Copper Cliff in Waters and Broder Townships. The other is the Beaver Lake-Vermilion River district west of the Whitefish Lake Indian Reserve No. 6 and south of Worthington and Whitefish in Lorne and Louise townships. The two districts are separated from each other by the Whitefish Lake Indian Reserve No. 6 on which white settlement cannot take place.

These two districts differ from the Sudbury pocket in many ways. A melange of road types weaving in and out among the hills, lakes and swamps results in a serpentine road pattern in contrast with the rectangular one of the Sudbury pocket. (Compare figs. 5 and 6). Ferries and fords are numerous here; they are seldom found in the Sudbury basin. Fourth class roads (local roads slightly traveled) are more prevalent in the Disseminated Agricultural Landscape Among the Ice-scoured Hills than in the Agricultural Landscape of the Sudbury Pocket. The population pattern is also irregular

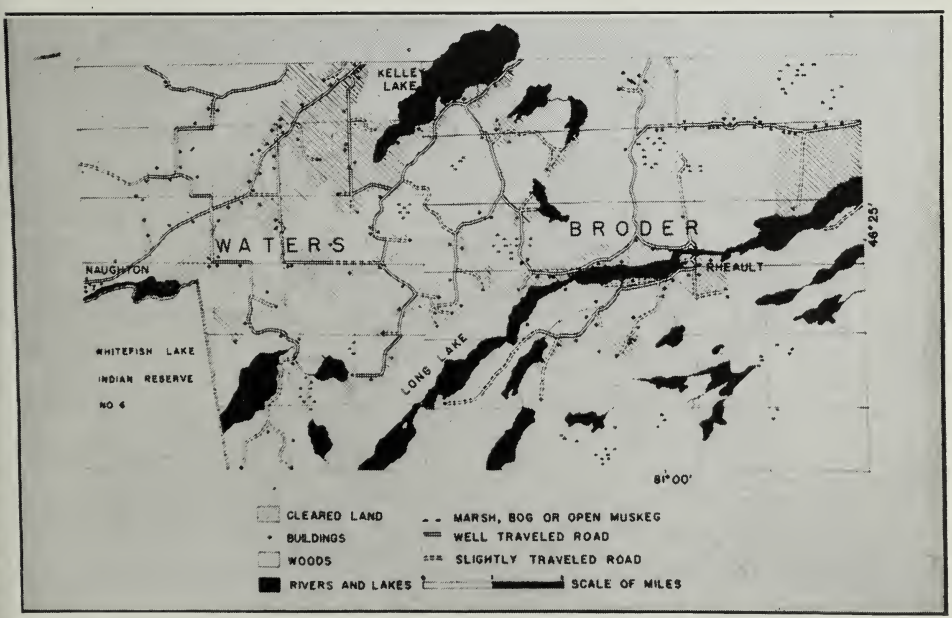

Fig. 5.—Dispersed Agricultural Settlement, Kelley Lake-Long Lake District, Sudbury Area, Ontario.

and the population density is not as great as that in the Sudbury pocket. There are only three or four houses to the square mile.

There are many evidences of pioneer farming in these districts, such as patches of cultivated crops interspersed in the second growth forest. A predominance of hay fields in which rock piles and stumps may still be seen. Whereas many of the farms in the Sudbury basin have been four-fifths or completely cleared, here the amount of cleared land is very small. These clearings appear like small islands in a sea of cut-over forest land. The cultivated fields of one farm often do not join the fields of the adjacent one. Sometimes a second growth forest of jack pine, birch and yellow poplar may completely hide one farm from another. Buildings are small and crude, and are constructed from poles, logs, and rough lumber obtained in clearing the land.

In these districts much of the land and forests pass through three stages of development. Between 1900-1920 the large lumber companies removed the red and white pine. Then followed the French Canadian "wood chopper" or "bush farmer" who was more interested in cutting the jack pines for mine timbers and ties, the yellow poplar for pulp wood, and the birch for fuel, than he was in clearing the land for cultivation. The bush-farmer stage is followed by the Finnish farmer whose persistent efforts and frugal living made cultivation of the land possible (in these two districts the Finnish farmers outnumber the French Canadians).[17]

In contrast with the commercial agriculture of the Sudbury pocket, farming in these districts is chiefly one of subsistence agriculture with few cash products. Some milk and vegetables are marketed in Sudbury and the mining towns. Dairying is becoming more important as shown by an increase in the number of Ayrshire cows. In 1939 a carload of

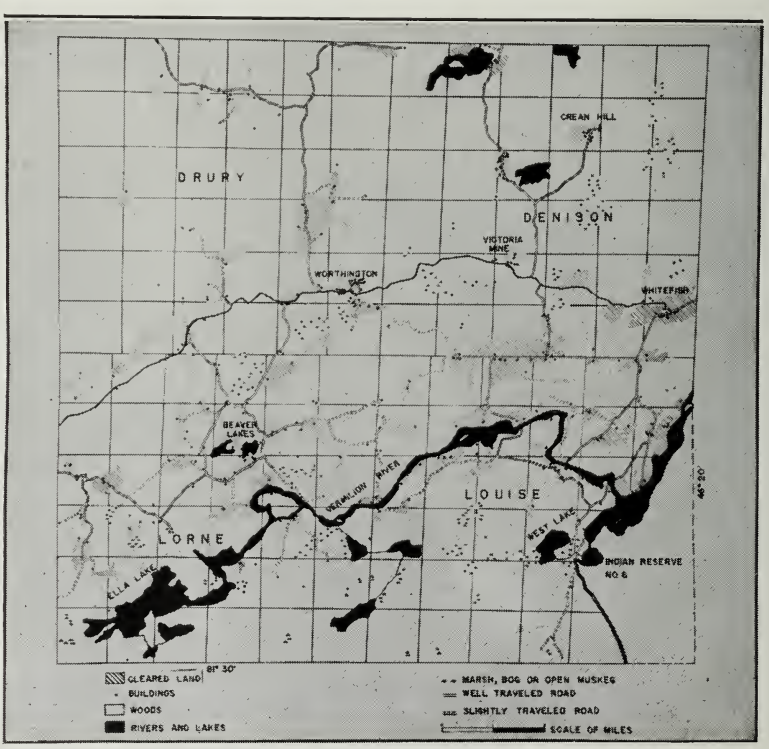

Fig. 6.—Dispersed Agricultural Settlement, Beaver Lakes-Vermilion River District, Sudbury Area, Ontario.

[17] Interview with Tom Thorpe, assistant forester in Sudbury, on August 14, 1939.

Ayrshire cows were shipped from lower Ontario to Worthington for the Beaver Lake-Vermilion River district.[18] Money is also secured by the sale of baled hay, and both pulp and fuel wood. The money from these small sales is used to purchase meager necessities that cannot be produced on the farm.

Settlement gradually goes on in these two districts. New roads are cut through the forest and old roads improved. The number of families and farms increase and the areas of farm land become larger and more continuous. Rapid agricultural expansion is not likely, however, and boom periods only occur in the mining industry of the Sudbury Area.

Although the climate is the same and about the same kind of crops are grown in both agricultural landscapes, farming in the Disseminated Agricultural Landscape among the Ice-scoured Hills is a battle against rougher land, poorer soil, and poorer drainage than in the Agricultural Landscape of the Sudbury Pocket.

Summary

Two distinct agricultural landscapes are found in the Sudbury Area primarily because of a difference in landforms and soil. Associated with the differences in physical features are the differences in cultural forms such as road types and patterns, distribution and density of population, acreage of cleared and cultivated land per farm, crop production, and stage of economic development. Both of the agricultural lanscapes are primarily dependent for their existence upon the saxicultural development of the Sudbury Area.

[18] Sudbury Star, August 18, 1939, p. 6.

THE SOIL FACTOR AND LAND USE IN BARBOUR COUNTY, ALABAMA

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Barbour County in east-central Alabama lies within two regions of the Upper Coastal Plain of Southeastern United States, the Clay Hills and the Southern Red Hills. In the Clay Hills or northern portion of Barbour County are found soils belonging to the Susquehanna series. In the Southern Red Hills portion, are found soils belonging to the Ruston and related series. Numerous cultural contrasts exist between the northern and southern portions of the county, many of which can be explained in terms of this soils difference.

The highest summit level of the cuesta produced by the Clayton formation which almost bisects the county is generally considered to be the line of demarcation between the Clay Hills and Southern Red Hills. The Clay Hills section is underlain by the Ripley formation which consists of gray to greenish-gray sands and clays. The southern portion is underlain by the Naheola formation which consists mainly of reddish sands, and which rests upon the white limestone of the Clayton formation.[1]

Northern Barbour County lies on the lower portion of the dip slope of the cuesta produced by the Ripley formation, and as a result, is maturely dissected. Its surface configuration is featured by broad, open valleys and some rather conspicuous narrow, steep-sided ridges. On the other hand, Southern Barbour County lies mainly on the upper portion of the dip slope of the cuesta produced by the Clayton formation. Hence its dissection has just begun and its surface configuration is featured by rather broad, open ridges and shallow, rather narrow valleys.

Despite these contrasts in surface configuration, the topographic factor is not the significant one in explaining differences in land use. For both areas have approximately the same amount of land in which, topographically speaking, agriculture is possible, even though in one case it is in valley bottoms and in the other on ridge tops.

The original vegetation of the two areas was similar, consisting of mixed deciduous and coniferous trees, including

[1] Lithic descriptions from "Geological Map of Alabama", *Geological Survey of Alabama*, 1926.

among others long-leaf and short-leaf pines and various species of oak, hickory, and gum. In both areas hardwoods were most common either on the ridges or poorly-drained lowlands, while pine was most common on slopes and on sandy areas. Coniferous trees were slightly more numerous in the southern area, comprising about 47 per cent of the total stand as compared to 38 per cent of the total stand in the northern area.[2]

More important than any other single physical elements in explaining contrasts in land use within the county is the soil factor. The Susquehanna soils of the northern portion have developed from the clayey Ripley formation and hence are rich in clays. The Susquehanna soils, which belong to the Red Podzolic group of soils, usually have a thin, yellowish A-horizon, lack a B-horizon, and are underlain by tough, compact clay subsoils. These clay soils, although richer in minerals than most sandy soils, have the disadvantage of being cold, wet, and difficult to fertilize. If they lose their A-horizon, and this has happened in this area because of careless cultivation and continuous cropping in clean-tilled crops, they become almost too stiff to cultivate by ordinary methods. The soils of the southern portion of the county belong mainly to the Ruston series, though the Norfolk and Orangeburg are also represented. The Ruston soils, developed in the sandy Naheola formation, are light gray to grayish-brown sands, loamy sands, and sandy clays with friable sandy clay or sand subsoils. They are slightly acid and rather low in mineral content, but have the advantage of being well-drained, easy to cultivate, and very responsive to fertilization.[3]

Not only present land use, but also past land use in Barbour County is closely related to the character of these contrasted soils series. When the county was first settled (between 1830 and 1840) the Susquehanna areas attracted the large-scale cotton producers, since its richer soils encouraged the large capital investment necessary to buy land and slaves. The Ruston areas were thus left to the small-scale pioneering farmers.

This contrast between the plantation economy of the north and the self-sufficient pioneering economy of the south continued even after the Civil War. It was not until commercial fertilizers came into common use that the yeoman farmers were able to compete with the white-owned, negro-operated plantations in cotton production. With this shift from a self-sufficient economy to a cotton economy, the amount of land in cultivation in the southern area increased rapidly, and accompanying this was a great increase in population. The present status of the southern area in these respects was reached about 1910.

The coming of the boll weevil in 1914-1915 had more serious repercussions in the northern than in the southern area. The best method of overcoming the ravages of the weevil is to plant early-maturing varieties of cotton. However, such varieties of cotton require light, well-drained soils, fertilization to promote growth, and thorough tillage before and after planting. It can be seen that the heavy clay soils of the northern area prevented all these measures from being carried on effectively. Also, by this time the farmers of the northern area were faced with a new problem. Because of continuous cropping in clean-tilled crops, the thin top soils of the area had been removed, leaving the tough clay subsoils exposed at the surface.

In contrast, the economy of the southern area was not seriously shaken by the boll weevil, although some efforts were made to diversify. Chief amongst the crops which were added was the peanut. Peanuts are utilized both as a cash crop and as a forage crop in hog production. They do best in sandy soils, since dark-colored soils discolor the hulls and thereby reduce their commercial value.[4] It is also true that when peanuts mature, they are apt to sprout and become rancid in wet, clayey soils. For these reasons, peanuts, which have proved so beneficial in bolstering the economy of the southern area, have never become a significant crop in the northern. Other crops which proved successful in the southern, but not in the

[2] Harper, R. M., "Economic Botany of Alabama, Part I", *Geological Survey of Alabama,* Monograph No. 8, p. 92 and p. 102.
[3] Soil descriptions from: "Soils and Men", U.S.D.A. *Yearbook*, 1938; Marbut, C. F., "Soils of United States", *Atlas of American Agriculture,* Part III.
[4] Sturkie, D. G., "Peanuts", *Alabama Experiment Station,* Leaflet No. 5.

northern area, are cowpeas, soy beans, velvet beans and pecans.

The one bright spot in the future of the northern area lay in the fact that several types of good native and imported pasture and forage grasses do well on its clayey soils, a condition not common in sandy areas. So about 1920, encouraged by this fact, white plantation owners began consolidating their farm units and turning cultivated land into pasture land. As can be realized, this process was a painful one, since it resulted in the dispossession of many already very poor tenant farmers. Despite numerous mistakes and handicaps, a farm economy based on cattle-raising as well as cotton production is now fairly well established in the northern area.

Thus, at the present time, mainly because of soil differences, numerous cultural contrasts exist between the northern portion and the southern portion of Barbour County. The northern portion is an area of decreasing population, of land abandonment, of large, white-owned farms operated by negro tenants, an area where pasture land is supplanting cultivated land, and where an economy based upon cattle and cotton is being substituted for one based on cotton alone. The southern portion is an area of static population, of small farms usually operated by their white owners, an area where rather intensive cultivation of cotton, corn, peanuts and other crops is supporting a cotton, peanuts, and hogs agricultural economy. Some of the present contrasts between the two areas are shown statistically in Table I, in which Spring Hill Township represents the northern portion of the county, and Reeders Mill Township, the southern portion.

TABLE I. COMPARATIVE STATISTICS*

Item	Spring Hill Twp.	Reeders Mill Twp.
Population per sq. mile	18.0	36.4
Per cent population decrease 1920-30	21	4
Per cent population negro (est.)	90	35
Per cent total area in farms	33	76
Per cent total area in crops harvested	15	41
Average size of farms (acres)	96	63
Per cent farm land cultivated	39	55
Per cent farm land in pasture	44	15

* Bureau of Census: 1930.

THE FACTOR OF POSITION IN HEMISPHERE DEFENSE

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A study of the geography of western hemisphere defense must, by the very nature of the subject, include the consideration of a multitude of factors. Many statements have been offered regarding our national needs for materials —strategic, critical, and essential—for defense.[1] Other statements deal largely with such topics as naval bases[2], the merchant marine[3], conservation of fuel resources[4] the Pan-American policy[5], the extension of the Monroe Doctrine[6], the foreign policy in relation to the establishment of a favorable exchange of goods[7], the possibility of invasion[8], and the Russian-Japanese-American Far Eastern policy[9]. Some, but by no means many, of these publications concern themselves to a degree with the factors of position. None, however, analyze the problem of United States defense entirely from the positional factor point of view. It is the purpose of this paper to present a discussion on this subject—the factor of position in hemisphere defense.

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Current events of a world-wide scope make this program of hemisphere defense as necessary as any other governmental function. In order to fully realize this critical international situation, we as geographers cannot over-emphasize geographic positions. Napoleon once said, "War is a business of positions," it is a question directly in terms of areas defendable and indirectly in terms of areas to be defended. The question of areas may also be considered directly in terms of items now produced and indirectly in terms of items that could be produced if the source of supply were lost.

The problem of areas and their positional relationships is a reality. Armies and navies do not move around ideas or concepts of ideology. Nor do naval and air bases rest on immaterial concepts of political theory. They exist and move in place. An area, plus other features, has position and time. Position and time constitute a reality. Therefore, a consideration of areas and their positional relationships constitutes a study in geographic reality.

There seems to be virtual agreement that our defense is concerned primarily with the Three Power Pact of Germany, Italy, and Japan with perhaps more than passing consideration to Russia. Defense is largely in terms of possible attack from the position of military, economic, and political aggression. In discussing the positional factor of defense, only attack of a military nature is considered here.

Two points are significant at this juncture. In the first place, in what form will attack come? Obviously the initial form would be by sea or by air. The nature of our defense must, therefore, base itself upon that point. In the second place, what are we as a nation defending? There are several points of view current, but the position taken here is that our first concern is the defense of the United States and her possessions. With these points in mind, let us look to the vital areas that require special attention. These areas are: (1) the Panama Canal and the Central Lowlands of the United States, (2) the eastern seaboard, (3) the St. Lawrence Lowland, (4) Alaska, (5) the Pacific possessions, and (6) the western seaboard.

Unquestionably our first interest to the south is security of the Panama Canal and the Central Lowlands. With our bases in the Caribbean region, we should be able to prevent the establishment of enemy bases on the Caribbean coast of South America, Central America, and on the islands of the Caribbean. Our second interest in southern defense is the prevention of enemy operating bases on the east coast of South America, particularly the sector south of the Brazilian bulge. It is 3600 miles from our base at Norfolk, Virginia, to Pernambuco at the tip of South America's eastern bulge. It is 3100 miles from Lisbon, the nearest European port, to Pernambuco. Europe is closer than the United States to this eastern coast of South America by approximately 500 miles. The cruising radius of our fleet is 2500 miles. Our bombers can cover 1500 miles. (To these figures the navy adds 10% and the air corps 20% to account for adverse weather conditions.) With our base at Puerto Rico, which will bring our influence 500 miles nearer Pernambuco than Lisbon, our fleet's effective cruising radius will cover the eastern bulge.

Shifting our point of view to Africa we notice that Dakar is 1700 miles from the eastern bulge of Brazil. The Germans have been very active in Dakar, whereas the rest of the French possession has been left relatively alone. Holding Dakar brings Pernambuco within range of active German influence. Rio de Janeiro is 2500 miles from Dakar. The Nazis in Dakar are closer to the whole eastern coast of South America below the bulge than are our bases in the Caribbean. The possibility of the establishment of enemy bases south of the bulge is apparent. Firmly based in this southern area, northward advance could follow.

Our third interest in southern defense focuses on the west coast of South America. Here the United States has a clear advantage, for the east coast of the United States lies vertically above the west coast of South America. This means that the whole of the United States is nearer to the west coast of South America than is Europe. The Panama Canal is 2600 miles from Valparaiso, Chile. (Practically within the 2500 mile cruising radius of our fleet.) The nearest European port is 8000 miles from Valparaiso. The nearest port in South Africa, Capetown, is 4000 miles away. There

are many islands in the Pacific, like Galapagos and Easter Island, that lie but a few hundred miles off the west coast and could be used as enemy bases. The United States, however, has naval and air outposts in the Pacific between these islands and Japanese island outposts.

Let us now consider our eastern seaboard and the St. Lawrence Lowland. Here is the financial, commercial and industrial heart of Canada and the United States. The St. Lawrence Lowland leads into the Great Lakes region, and the Lake Champlain-Hudson River trough. Here is produced 75% of our "heavy" industries — armaments, automobiles, iron, steel, and coal. Here is produced 75% of our wheat, 65% of our corn, 40% of our copper, 74% of our zinc, 46% of our lead, and 100% of our flax. In this heart area are found our largest cities, the center of population, and the focus of railroad transportation and hydro-electric power. To guard this area we depend upon the bases of Iceland, Newfoundland, and the Azores. German military bases in Norway and Africa are only 2000 miles from Newfoundland, 1600 miles from Iceland, and 1500 miles from the Azores. The Azores are situated 2100 miles from New York, Iceland 1300 miles northeast of Newfoundland, and Newfoundland only 1000 miles from New York. The best defense for both Canada and the United States is control of the Atlantic.

The situation in relation to the defense of the western seaboard, at once, demands the discussion of the defense of Alaska and our Pacific possessions. The question also must include Japanese and Russian far eastern military activity. Our island in Bering Straits, Little Diomede, is only two miles from Russian owned Big Diomede. Here the Russians are building air bases. The difficulty of maintaining Big Diomede is impossible for it is 2500 miles to the nearest point on the Trans-Siberian Railroad and there are no other roads. Alaska is rapidly becoming a powerful military base, both coastal and internal. The real value of Alaska lies in the southern extension—the Aleutian Islands. This string of islands extend from Alaska toward Japan. Dutch Harbor, in the Aleutians, is 2500 miles from Yokahama and Tokyo, the heart of the Japanese Empire, while it is 4300 miles from Yokahamo to Seattle. Japan, then, is within the 2500 mile range of our bases—the southernmost tip of the Aleutian Islands, and not the west coasts of continental United States. If we reverse the situation we find the very heart of Japan within striking distance of Uncle Sam.

Japan has also the Pacific possessions to contend with. Chief of these possessions is Hawaii. It is 2000 miles from the Hawaiian Islands to the west coasts of the United States—too far for an air force attack. With the fortification of Galapagos, no fleet could operate between Alaska, the Hawaiian Islands, Galapagos, and the Panama Canal. Japanese fleets are built to operate in Japanese waters with frequent supply bases. The Japanese navy cannot carry fuel enough to attack the west coasts of continental United States.

The factor of position in hemisphere defense is truly a study in geographic reality.

GOPHER-HOLE BARITE MINING IN WASHINGTON COUNTY, MISSOURI

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One of the most critical problems of human readjustment in the Ozark Province is that associated with gopher-hole barite mining in Washington County, Missouri. Barite, or "tiff," as the natives call it, is a soft, heavy, white mineral used principally in the manufacture of paint and as a "heavy mud" in the drilling of oil wells. In Washington County the tiff occurs in a thick layer of mantle rock from which it is easily extracted. Most of the mines are small hand operated workings, but stripping operations have expanded considerably since their introduction in 1924. The hand mines, which belong to a type known as gopher-holes because of their small size, consist of shafts approximately five feet in diameter and usually 20 feet or less in depth. As the work proceeds, the lower part of the shaft is enlarged in the shape of a jug, the extent of the excavation being limited by the danger of collapse of the loose mantle rock. Equipment consists of a log windlass, a bucket made from half an oil barrel and a "rattle box," or shaker for separating the barite from clay and other surficial impurities. For more thorough cleaning, a small handmade pick-hatchet called a "pickawee" is used to chip off incrustations of iron oxide. The mine crew consists of two men each of whom may earn, under favorable circumstances, $2.00 or more per day. However, if the price of barite is low, the worker lazy or the deposit poor, earnings may be as little as $2.00 per week.

Most of the hand-operated mines are located on old Spanish grants about 60 miles south of St. Louis between the towns of Desoto, Jefferson County, and Potosi, Washington County. From Spanish times is inherited the paternalistic system under which operations are conducted. Land owners build on their property small cabins which are offered, rent free, to miners as an inducement to settle and produce barite. Barite dug on the land is sold either to the owner or to buyers who pay the miners for the mineral and credit the owner with a royalty based on tonnage. Despite increasing competition of lower cost areas using machinery, hand mining proved satisfactory to both miner and land owner until the Depression. At this time, when business began to slacken, large numbers of men thrown out of other employment in neighboring areas went to Washington County, because barite digging offered an easy means of making a bare living. As a result of this influx of migrant workers, a great increase in barite production occurred. The owners felt morally obligated to buy from the miners on their land, but, in absence of a favorable market, could not also receive tiff from outsiders. Hence, they discontinued purchases of the mineral from land other than their own and labor troubles followed. These disagreements have largely been settled, but the problems of the native barite miner are still unsolved.

The indigenous hand miner is competing with machinery, and the demand for his product has decreased due to expanding production of high grade, low cost barite in Tennessee and elsewhere. Furthermore, because of the practice of mining the richest material available, the deposits are becoming progressively leaner and the output per man lower. At present, much of the land has been worked several times in a rather haphazard manner; hence, it is now difficult to find virgin ground. Ultimately, this condition, together with increased local mechanical mining, will eliminate many of the native hand miners. This constitutes a serious problem, for most of the miners are unable to adapt themselves to new tasks. Unfortunately, these people of the tiff district are almost completely uneducated, and those who are more than 20 or 30 years of age are, as a rule, too fixed in their ways to learn new methods of making a living. A consid-

Fig. 1.—Higher type native miners, shaft head, windlass, and rattle box.

erable part of the group, therefore, is too old to learn, but too young to receive government pensions.

Inbreeding through many generations and diet deficiencies have seriously reduced the ability and aptitude of the tiff-miners. Most of them are members of French families who settled in what is now Washington County in the eighteenth century and who have remained in the same neighborhood, rarely marrying outside the group. Diet inadequacies are due partly to poverty, partly to the miners' aversion to agriculture. Only a few barite diggers raise gardens, and, because of steep hills and stony soil, farms are few. As a result, fresh vegetables must be shipped from other areas at prices which place them beyond the reach of the miners. Fresh meat, likewise, is not available in sufficient quantities. Some miners raise a few chickens or perhaps one or two pigs; however, the dangers presented by gopher-holes exclude cows from the area. Consequently, subsistence depends almost entirely upon bacon, dried beans, potatoes, flour and canned goods. Diet deficiency is aggravated also by the ownership of one or more old cars by each family. Money needed for food is spent for transportation, which, although convenient, is usually not necessary.

For the future, it is essential that plans be made to prevent increasing numbers of unemployed tiff miners from becoming public charges. Improved employment conditions elsewhere will attract most of the migrant tiff diggers, but the native miners will remain to constitute a major local problem. Probably the best solution lies in the education of the young people for new occupations. A few may engage in crop raising, despite unfavorable soil and land slopes, and some may learn stock raising, although this occupation requires considerable capital and employs only a few workers. Larger numbers may learn various handcrafts, and, if electric power were made available, small local factories could be established to utilize the cheap labor. With proper forest management, it is probable also that a few will find employment in lumbering.

Older miners who are incapable of learning new skills can continue hand mining at a fair profit by working small rich deposits in the pits made by mechanical mining. This employment will be available until the barite deposits become exhausted possibly fifty years hence.

GROWTH OF ROBINSON, ILLINOIS

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Robinson is only one of the many small cities of southern Illinois that has experienced a somewhat uniform growth over a period of years. Although located on the undulating terrain of the Illinois till plain and only a few miles from the fertile alluvial lands of the Wabash River, it is not essentially an agricultural community. More so, it is a community whose economy has resulted from a combination of manufacturing, agriculture, transportation, and human initiative.

Early Development. — Palestine, six miles east of Robinson, was the first settlement in this section of the state and became the county seat of Crawford County when the latter was organized in 1818. As new communities developed in the western portions of the county the necessity of removing the county seat to a more central and convenient location became more and more apparent. In 1843 the present site was chosen by popular vote, although Hebron and Hutsonville were also contestants for the honor and offers of land were received from many other points.

Early growth was slow, the estimated population in 1865 being placed at 400 persons. Prior to the Civil War, there was little money in circulation. Many of the merchants sold goods on a year's credit and were paid in crops or livestock during the summer and fall. In some cases they fattened this livestock on their own farms, owned packing houses on the Wabash River, the principal commercial artery, and shipped pork, beef, and grain to New Orleans. These conditions remained relatively unchanged until the Paris and Danville Narrow-gage Railroad was extended to Robinson in 1875. The railroad gave Robinson a decided advantage over its competitors on the Wabash, namely, Palestine and Hutsonville, these two having more-or-less overshadowed their upland neighbor prior to that date. Five years later an east-west line (Springfield, Effingham, and Southwestern) gave the village added commercial advantages and helped to place the trade on a firmer basis. Manufacturing came gradually: saw mills and grist mills first, then an ice plant, and finally a glass factory.

Development as an Oil Center.—The discovery of petroleum in southeastern Illinois caused Robinson to experience a rapid growth in population and all lines of activity, the development in Crawford county reaching a peak about 1907. By this time the two railroads had become a part of the Big Four and Illinois Central Systems respectively and machine shops, tank factories and a small refinery were attracted by 1908.

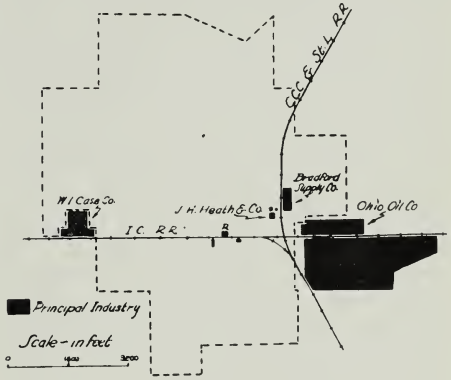

Fig. 1.—Robinson's industries are located along the railroads and the principal ones are on the urban periphery. (R indicates Robinson Casket Company.)

Since that time the growth of the community has been closely associated with the petroleum industry. The population increased 100 per cent between 1900 and 1910, then declined slightly, but has increased again within the last fifteen years. This can be attributed in part to the growth of the refinery.

The locally owned refinery was purchased by the Ohio Oil company in 1924 and the plant capacity was increased more than 500 per cent within a period of about two years, and subsequently enlarged on two other occasions. This plant is handicapped by the absence of a nearby metropolitan market, so most of the

products are marketed within the local area. Only lubricating oils, road oils, and fuel oils offering competition in Chicago, St. Louis, and Cincinnati markets.

More Recent Industrial Growth.—The second important manufacturing plant is W. I. Case and Company locally called the "pottery", which manufactures a complete line of bathroom fixtures. It had its origin about 20 years ago and in 1924 was manufacturing only three items. Other products have been added to meet competition and the company now serves a national market, and has a small export business to South America. This plant, employing 300 persons during the peak season, has not grown because of any natural advantages of the region, although adequate labor and transportation facilities have permitted it to develop unhampered. Forty per cent of the clay is imported from England and the rest comes from Indiana, Kentucky and Tennessee, while other materials arrive from Illinois and the Dakotas. Local oil products are used, but their price is based upon Tulsa freight rates so this results in no locational advantage.

A combination dairy-candy-beverage plant, has also added to the industrial diversity within the last quarter of a century. It began in a small way and supplementary items were added and the plant capacity increased at intervals as the need arose. It, however, is more dependent upon local materials and local markets, as only the candy is sold beyond a limited area in southeastern Illinois and adjacent Indiana.

Other types of manufacturing are a casket factory and two oil well supply concerns. The origin of the latter dates to the previous oil development, but their present status is indicative of the recent growth of the industry in southern Illinois.

The Recent Oil Boom in Southern Illinois.—In February, 1937 Pure Oil's test well at Clay City, about 50 miles southwest of Robinson, ushered in a new era of oil speculation and development in southern Illinois. Although this new activity has been almost entirely outside the limits of the earlier oil field, the older cities to the east, Robinson and Lawrenceville especially, have been the indirect recipients of renewed growth and increased prosperity. The refineries have expanded their capacity and are connected by both rail and pipe line with many of the new fields. The drilling and oil well supply companies, as already mentioned, have experienced a suddenly increased demand for their products and services. In fact, the Bradford Supply Company moved its main offices from West Virginia to Robinson early in 1938.

Conclusion.—In conclusion, Robinson's development has undergone many changes. Settlement was retarded until the present century because the village was only one of several small market centers that served the agricultural population of the nearby countryside. Then the discovery of oil caused an immediate increase in population, which was accentuated by the construction of the Wabash Refinery in 1915. The refinery has remained the major supporting industry, but other manufacturing establishments were built by local men or were attracted by the cheap land, low taxes, convenient transportation facilities, or the abundance of labor. The labor supply can be attributed to at least two factors. (1) Many families moved to Robinson during the oil boom and then remained after peak production had been reached. (2) The greater mechanization of agricultural practices produced a surplus of farm labor that was eager to accept other types of employment.

Residential expansion has progressed consistantly, but not rapidly. At present there is a shortage of housing facilities and rents are abnormally high. This can be attributed to the greater demands of the last few years which have paralleled the current industrial expansion. In brief, Robinson no longer has the character of a one industry town. Manufacturing is sufficiently diversified that the community life and prosperity are only partially dependent upon the petroleum industry.

ORIGINAL FOREST VEGETATION IN A GLACIATED AREA

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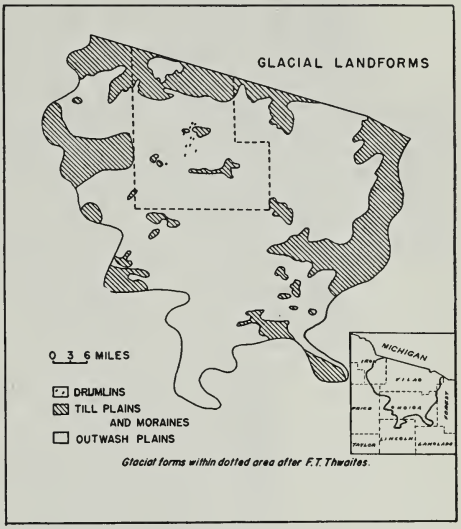
The Northern Lakes Region of Wisconsin may be considered as an area representative of the glaciated portions of the Upper Lakes States Region. Approximately sixty percent of the surface of this sub-region is composed of outwash materials, parts of which are extremely level while other portions are broken or choppy. These latter irregular surfaces are due to the presence of numerous kettle holes or post-glacially eroded channels. The remaining forty percent of the region, primarily found in the peripheral sections, has a surface of till material. The surface configuration of the ice deposited debris ranges from rolling through choppy to rough. In all portions of the region lakes, marshes and swamps are to be found located in kettle holes, post glacial channels or blocked pre-glacial valleys.

The natural dynamics of forest ecology in this region of youthful landforms was abruptly terminated with the advent of lumbering activity during the late 19th and early 20th centuries. Since the last ice retreat many adjustments of vegetation to the numerous environmental conditions had been made, while others were in progress when the disruption by man occurred. One of the chief adjustments of vegetation to habitat was found to be between forest species and glacial material, for as can be seen from a comparison of the two accompanying maps, vegetational types in the core of the area, which is composed of glacio-fluvial material, contrast with those in the peripheral sections where till materials are found. In general, the exclusively softwood, predominantly softwood and the mixed forest associations prevailed on the more sandy and droughty outwash while the predominantly and exclusively hardwood (including hemlock) associations were limited to the heavier morainic materials.

The close correlation between glacial surfaces and vegetation can readily be shown by representative survey sections in the contrasting glacial types and noting the forest species which were found there by the surveyors of the original land survey. On the section lines bounding section 33 in T. 42 N., R. 10 E., an area of Plainfield Sand soil developed on a flat, sandy outwash surface, softwoods were found exclusively. Red pine (*Pinus resinosa*), white spruce (*Picea glauca*), black spruce (*Picea mariana*), tamarack (*Larix laricina*) and balsam fir (*Abies balsmea*) were the softwood species supported. In contrast, a survey section (Sec. 32, T. 42 N., R. 12 E.) in rolling morainic material (Kenman Silt Loam) revealed yellow birch (*Betula lutea*), sugar maple (*Acer saccharum*) and hemlock (*Tsuga canadensis*) on the well drained sites with some white cedar (*Thuya occidentalis*) and tamarack in the swamps. Many portions of the outwash plain contain varying amounts of reworked till of earlier origin, allowing for the presence of a greater component of fine soil particles in such areas. (Example: Sec. 9, T. 41 N., R. 8 E.; Vilas Sandy Loam). Likewise, sections of ground moraine in the eastern marginal areas contain a fair percentage of sand particles in the glacial till. (Example: Sec. 30, T. 41 N., R. 11 E.; Kennan Fine Sandy Loam). In both instances the vegetational cover consisted of mixed forest species.[1]



The representative, contrasting, forest associations were found almost exclusive-

[1] See Wilde, S. A. The Relation of Soils and Forest Vegetation of the Lake States Region, *Ecology* Vol. 14, No. 2, 1933, pp. 94-105 for a detailed treatment of relation of forest vegetation to soil texture, structure, moisture content and parent material.

ly on sites where root penetration was entirely above the ground water level. Surfaces intermediate in height between swamp and upland levels where roots were periodically influenced by the ground water level had different admixtures of soft and hardwood trees. Swamp lands supported still other forest associations, the particular type dependent upon the variety of peat present and the percentage of mineral matter contained in the "soil".

The distribution of original forests in this geographical area was of great significance in determining the present cultural patterns. The highly coveted pine timber of the outwash plains was responsible for the extension of railroads into and through those sections. A few of these routes remain as rail lines while others have been converted for use as automobile roads or fire lanes. Likewise, many of the settlements of the pineries, originally functioning as lumber towns, are now flourishing recreational settlements. The hardwood lands, on the other hand, having been lumbered later, contain fewer cultural phenomena, as portable sawing equipment in use later and the trucking of logs to previously established settlements lessened the necessity of town and railway construction in the morainic sections. The apparent anomoly of greater concentration of agricultural development on the light, droughty outwash instead of on the heavier more fertile till material is primarily due to the fact that the latter areas are often excessively bouldery or extremely irregular in surface. Furthermore, by the time most of the hardwood lands were logged over few additional acres were being cleared owing to the occurence of the nation-wide agricultural depression.

WATER IN SOUTHERN ILLINOIS

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The portion of the State of Illinois south of the Baltimore and Ohio Railroad, or south of a line drawn eastward across the State from St. Louis, will be called Southern Illinois in this paper. As a cultural feature this boundary line exerts no influence on Southern Illinois, but as a physical feature, it marks the southern limit of thick glacial drift.

In two-thirds of the state, ground water is tapped for 80% of the public water supplies. In the southern third 75% of the public water supplies are of surface origin. (Fig. 1).

The problem of this paper is two-fold: (A) to analyze the factors responsible for the large number of surface supplies, (B) to understand the problems of rural dwellers and communities dependent on these supplies.

A study of environmental factors is of primary importance.

1. The character of the bedrock.—Most of the bedrock of Southern Illinois (fig. 2) is Pennsylvanian. About four-fifths of this series consists of impervious shale, with alternating seams of coal, dense limestones and sandstones. The thicker sandstone formations occurring in the lower portion of the series contain salt water. Other sandstones yield small supplies of fresh water to shallow wells, but even here the degree of mineralization is considerable.

The compact Devonian (fig. 2) limestone in Union and Alexander counties are unimportant as aquifers. In the Mississippian series, (fig. 2) limestones with solution cavities and sink holes are the best water bearers. Farm wells in it are only relatively successful, since a sharply defined water channel must be tapped for a supply.

The Tertiary gravels on the southern border of the state are good aquifers.

2. The character of the mantle rock and soil.—Pleistocene glaciation has left its indirect mark in the water laid sand, silt, and gravel on the large floodplains. On the upland, the thickness of the drift varies from thirty feet to ten feet near the southern limit of glaciation. The sand and gravel lenses of the drift contain sufficient water for small consumers. The northeastern quarter however, is underlain by considerable areas of impermeable drift. The loess or loess like material originating from the floodplains of the larger streams decreases in thickness with distance from the source. The proportion of clay, however, seems to increase, resulting in heavier and less porous soils in the eastern than in the western part of the state.

Fig. 1.—Seventy-five per cent of the public water supplies of Southern Illinois are of surface origin. (Drift is used in welldrillers' sense: unconsolidated material.)

Fig. 2.—The Pennsylvanian, consisting of impervious shale, seams of coal, and dense limestones and sandstones, dominates Southern Illinois.

The upland soils, derived from these parent materials are modified Gray Brown Podzolic soils without normal profiles. Characterized by claypan, they are acidic, low in organic matter and in all elements of plant food. Thus, their water absorbing capacity is low, yet their water holding capacity for surface supplies is great.

3. The relief and drainage. — The greater relief of Southern Illinois is evident on the map of the State showing major contours. The unglaciated Ozark ridge, classified as rough plain, is at an average altitude of 600-700 feet and above the adjacent area by 200-300 feet. The glaciated zone, only thinly mantled with drift, shows preglacial lines only slightly changed. In contrast to the rest of the State in which glaciation was relatively recent, the normal cycle of erosion has advanced farther.

Bounded by the Wabash, Ohio and Mississippi systems; the Kaskaskia, Big Muddy, Little Wabash, Embarrass, Saline and Cache are well developed systems within the State. Distinctly flat interfluves are limited, and runoff and seepage to the drainage channels is rapid, limiting ground water storage but facilitating surface collection in the dammed valleys of small streams and creeks.

4. The character and distribution of precipitation.—Located in the transition zone between the humid continental and humid subtropical climates, Southern Illinois has a slight tendency toward a spring and early summer maximum of precipitation. The average precipitation of 42.38 inches (50 year period) is well distributed with 3½ inches or more recorded for each of seven months. Two months have over four inches and only one month less than three inches. Averages, however can be very misleading; this past year the average was about 32 inches, and the distribution unsatisfactory from the standpoint of surface water supply.

The rainfall is largely of thunderstorm origin. Thus variability from season to season is pronounced and within a short distance there is a wide range. The runoff resulting from the summer downpours is rapid, much of it is evaporated or used by vegetation, and only the cyclonic storms of winter bring the maximum opportunity for the replenishment of ground water resources.

5. Cultural factors affecting ground water.—In the coal mining district, water which enters the mines must be pumped out to facilitate mining operations. This under-pumping lowers the water table.

Clean cultivation, the removal of forest and sod, and the drainage of wet lands hasten runoff. Again, subsequent recharge of ground waters is restricted. Thus the environmental factors of rough plains, impermeable soil, well developed drainage systems, and character and distribution of rainfall which are hampering ground water storage, favor man in surface water storage.

Three traverses were made to sample water supplies of rural areas.

The floodplains.—The Mississippi floodplain in the vicinity of Fountain Bluff demonstrates the ease with which ground water is obtained. A pipe with a screened point is driven down from 20-50 feet. A pump is attached to the upper end of the pipe. This locally is not a "well", but a "pump".

In Gorham, most water is hard. It has to be "broken" for washing and drinking. Cistern facilities seem to be limited to the wealthier class, for there are but ten cisterns in a population of 600. The Missouri Pacific Railroad has a ten-inch well bored to a 90-foot depth. The water must be treated with lime and soda-ash for locomotive use.

Sand Ridge, nearer the Big Muddy than the Mississippi, taps soft water at about 33 feet. Fortunately, for the sand precludes the construction of cisterns, this water is adaptable to all household uses.

The ease with which water is obtained is duplicated on the Wabash, Ohio, and the larger tributary floodplains of Southern Illinois.

The Uplands.—The upland traverses were in two genetically different regions. The unglaciated Ozark ridge of considerable local relief contrasts markedly with the flat interfluve of impermeable drift overlain by thin loess or loess-like material.

In the seven mile traverse of the Ozark Ridge on U. S. 51 between Cobden and Carbondale on 31 farms there are only 8 wells, dug to 35-40 foot depth. The yield is undependable, the water hard.

Cisterns are used almost exclusively for household and stock purposes, supplemented by ponds for stock and spray

mixtures. The ponds are in part dammed up draws, in part excavations of five or six-foot depth located strategically to catch runoff. With normal rainfall many ponds last through the summer, while in years of rainfall deficiency as 1935 and 1939, wells, cisterns and ponds were dry and water was purchased from Carbondale. On a number of farms additional water could have been collected in cisterns but either man takes a chance or the cost of putting in an emergency cistern is too great. Assuming that this sample is typical, one concludes that the unglaciated Ozark Ridge depends on surface water supplies almost exclusively.

The ten mile upland traverse southward from Pyramid (Junction Illinois 15 on U. S. 51) lies on the interfluve between tributaries of the Big Muddy and the Kaskaskia system. The data are from a smaller number of cases (18), as the farms are of the general farming type in contrast with the fruit farms of the Ozark Ridge. The dependability of the wells fluctuates with precipitation. During a period of cumulative rainfall deficiency in 1934 and 1935, some of these wells went dry. A few farmers bored two-inch holes from 5-18 feet into the bedrock to tap lower aquifers, but their water has not been as palatable since that time. Since the hardness of the water varies, cisterns are supplemental for general household use or laundrying. Noteworthy exceptions were the two rural schools which had cisterns only. As wells and cisterns on one-half the farms were of the "old oaken bucket" type, stock ponds were considered essential labor saving devices.

The uplands wells thus far discussed have been relatively shallow. Their yield, however, suffices the village household or average farm demand. Stock or dairy farmers have of necessity sunk their wells to one of the water bearing rock strata which assures them of a permanent supply. Thus one may conclude that the relatively shallow upland wells vary with topography and soils, and on the basis of these traverses the Ozark Ridge is poor in ground water and the northeastern quarter underlain by impermeable drift depends on wells supplemented by surface waters.

Municipal Water Supplies.—In the northern third of the State, wells of varying depth tap the copious sandstone aquifers. In the Central and Northern thirds drift wells also yield abundant water of good quality. Good and abundant water is available at low cost to municipalities. At Champaign-Urbana, the minimum domestic rate is $1.67 per quarter for 4500 gallons or 36c per 1000 gal. per quarter. In the Southern third of the State there is neither adequate glacial drift nor bed rock to yield good water in large quantities (the drift wells on map use "drift" in well-drillers sense as unconsolidated material.)

The Coal Measures (fig. 2) which are meager in ground water have in places sufficient supplies for towns of 900-1200 population (as New Baden, Steeleville, Trenton, Red Bud, etc.) Cities over 7,000 however, such as Marion, Williamson County, and Carbondale, Jackson County, had wells at depths varying from 400-960 feet. The water contained considerable mineral matter of which sodium chloride was the most objectionable, and since the maximum pumpage was not enough to furnish the domestic users with an adequate supply, surface supplies were provided.

The karst limestones furnish water to several towns, the largest Anna (3500). During the 1934 drought the Anna city wells supplied the domestic needs of the town, the State Hospital for the Insane (2210-2400 population) and the industrial needs of the Illinois Central Railroad. The total capacity of all wells was needed for this emergency. Whether the wells could supply this amount indefinitely is not known. Residential consumers pay 62.5c per 1000 gallons per quarter. (These rates includes the new filtering plant costs installed 1937.)

As indicated in fig. 1 surface waters from rivers, and impounding reservoirs supply 63 communities. (The map omits municipalities who buy treated water from neighboring communities, [East St. Louis alone serves 11 municipalities] nor is any attempt made to show the distribution of railway, mine or industrial reservoirs).

The Mississippi, Ohio, Wabash, Kaskaskia, Big Muddy and some of their tributaries provide municipal supplies. But neither the cost of developing a source nor the provision of an adequate supply in drought years is a pressing problem.

Communities without an adequate supply from streams must impound water.

Their problems include: selection of a reservoir site, buying land for the reservoir, constructing a dam, and in common with river supplies there is the cost of laying supply pipes, and erecting a filter plant. It is self-evident that the financial obligations of such an undertaking are considerable, not to mention the continuous cost of treating water. Usually little more than the actual reservoir site is owned by the water company. Since there is no control over the use of the watershed cultivation may at times cause the "solids" content of water to be high and sedimentation of reservoirs necessitates some dredging. Relatively small watersheds may furnish an abundance of water provided adequate storage is possible. Reservoir surface must be in proportion to storage capacity to reduce evaporation. Data for the following cities illustrates the point.

City A Drainage basin 2560 A, Storage 392 million gallons, Lake surface when full 145 A.
City B Drainage basin 2816 A, Storage 225 million gallons, Lake surface when full 85 A.
City C Drainage basin 5862 A, Storage 760 million gallons, Lake surface when full 128 A.

City A seems to be at a disadvantage in reservoir surface as regards evaporation, and shallowness may cause the water to be excessively warm in summer.

Domestic water rates vary. Some municipalities which tap the almost unlimited river resources pay as little as 33 1/3c per 1000 gallons quarterly, most other surface water users have much higher rates, varying from 33 1/3c to $1.16 + per 1000 gallons per month. This high cost of water, in part a result of the large investment necessary for impounding reservoirs, practically bars water systems in communities of less than 2000. Under W.P.A. aid one system was installed in a town of 1,100, but a previously existing lake was utilized, thus not charged against the cost of the system. A unified water plan would do much to reduce water costs for municipalities, mines and industries.

So far we have assumed an unfailing supply of water. However, variability in annual and seasonal precipitation causes much concern to the Southern part of the state. Cumulative rainfall deficiency the past year caused the cyclonic drizzles of winter to be absorbed by the parched ground. The early spring rains, the most important source of reservoir replenishment, have been below normal in amount. Although several million gallons of runoff were added to reservoirs in early April the cumulative precipitation deficiency January 1 to April 30 is 5.11 inches (Carbondale data).

The dependence of surface water supplies on rainfall, especially on rainfall that furnishes runoff is clear. Of course, an actual shortage of water need never occur if sufficient storage is available, however the cost of providing that additional storage is, at present, too high for most communities.

THE URBANIZATION OF SOUTHERN ILLINOIS AND ITS RELATION TO NATIONAL DEFENSE

JOSEPH E. VAN RIPER
Southern Illinois Normal University, Carbondale, Illinois

The growing crescendo of national defense is being felt more and more in the everyday life of the people of Southern Illinois, but probably to an even greater degree than in most other portions of the United States. There have been whisperings in the wind that new defense industries may enter the area. These may be only whisperings, but they are producing new hopes for thousands of Southern Illinois residents. These people need a new source of regional income, and need it desperately. This portion of the state is due for some kind of pronounced change in its general welfare. Whether or not this change will be to the good, remains to be seen, but to geographers, any change in the economy of an area should be of special interest, and therefore a brief summary of present conditions is presented here.

A glance at a map showing the distribution of urban agglomerations in Illinois reveals a compact cluster of urban aggregates in the southern part of the state exceeded only in the Chicago and East St. Louis metropolitan areas. (See Fig. 1.) The population center of this "scattered big city" is located a short distance northeast of Herrin, and approximately 200,000 people live within a radius of 25 miles of this center.[1] An unusual feature of this area is the small size of its cities. West Frankfort is the largest of them, and has a population only slightly more than 12,000. Most of the towns have between 1,000 and 5,000 residents. A closer view of this area shows that the pattern of these towns and cities has an even texture, only the small agglomerations showing a tendency toward grouping. (See Fig. 2.)

Mining is the basic economy of this urbanized area, and most of the agglomerations are, or were, mining towns. The saxicultural function however, is most dominant in the smaller centers. They have a much lower percentage of commercial establishments to total population than the larger towns, and this percentage has steadily declined with the advent of paved roads and the automobile. To a stranger, these small towns seem much smaller than they actually are because their business districts are so undeveloped. West Frankfort, Herrin, Marion, and others are important regional marketing and residential centers, and many of them have large coal mines near their borders. The most remarkable fact concerning these urban centers is their lack of manufacturing, other than the local type such as bakeries and ice plants. The regional service function is closely linked with mining, since it serves the small mining towns and the rural population, a large proportion of whom are part-time miners when employment is possible.

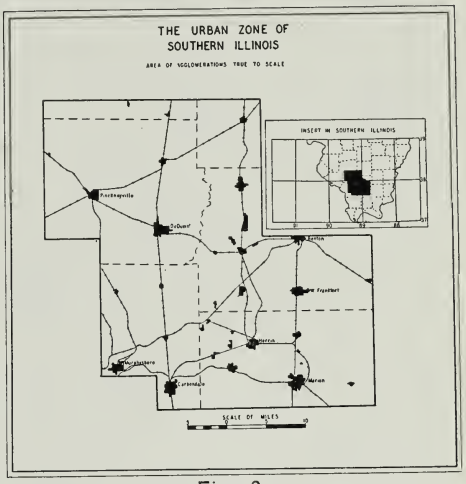

Fig. 2.

The inter-urban areas show a density of population much higher than in most other portions of the state. Many of the farms are part-time in character, and are small in size. In a survey made of three townships in the center of the area under discussion, it was found that 40

[1] Parrish, John; *"Labor Supply in the Southern Illinois Industrial Area"*; Report prepared for the Construction Division of the National Defense Commission; 1941.

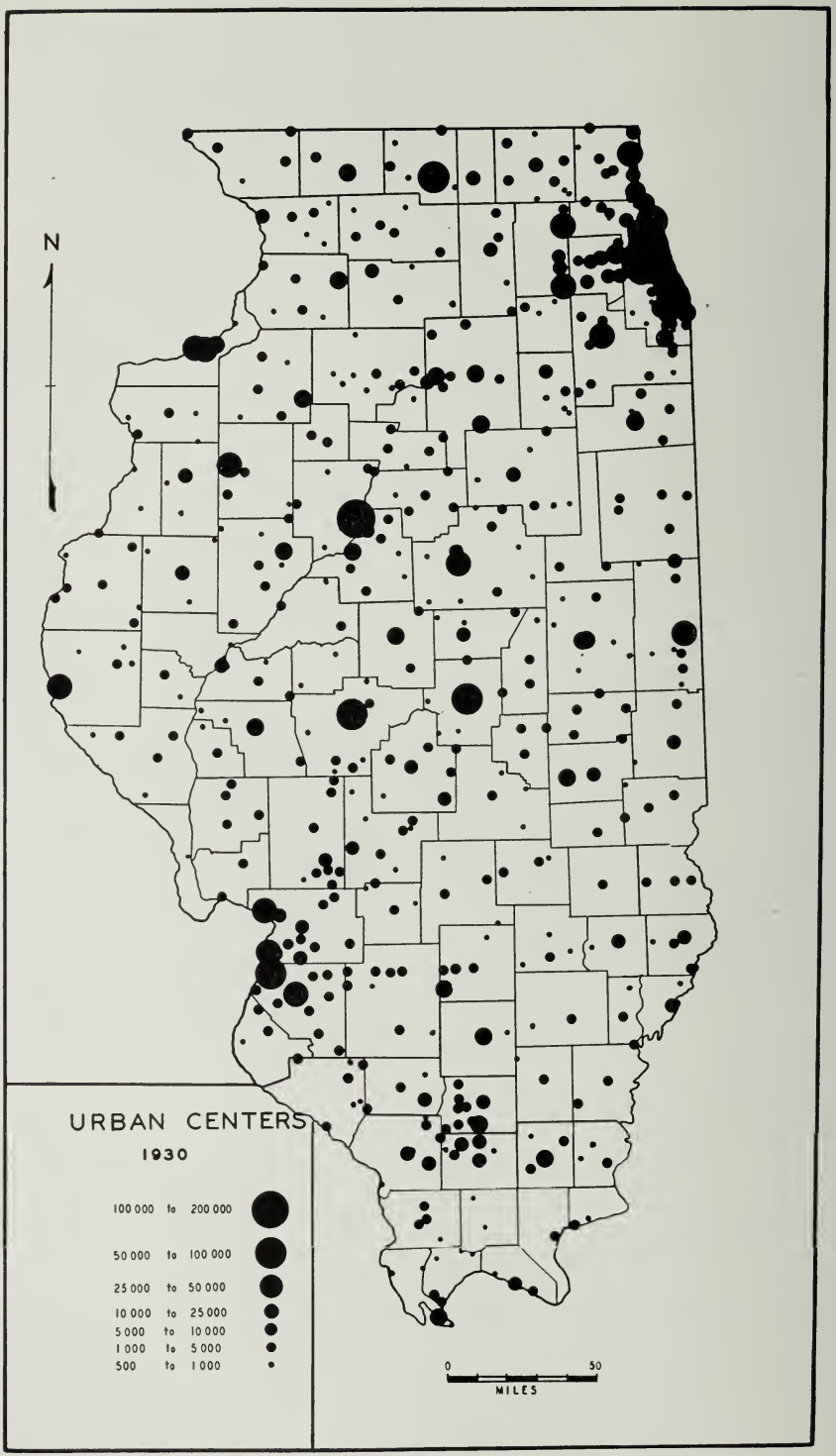
N
URBAN CENTERS
1930
100 000 to 200 000
50 000 to 100 000
25 000 to 50 000
10 000 to 25 000
5 000 to 10 000
1 000 to 5 000
500 to 1 000
0
50
MILES

Fig. 1.

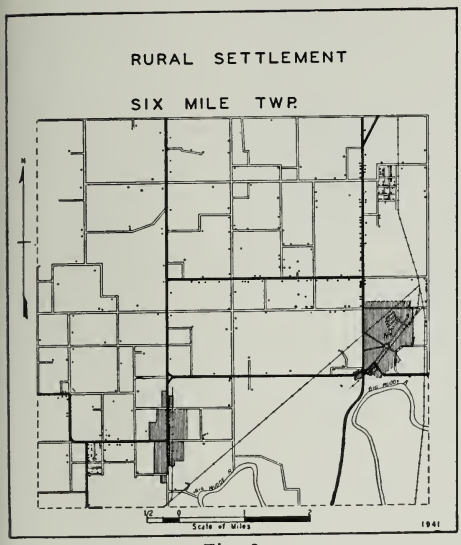

Fig. 3.

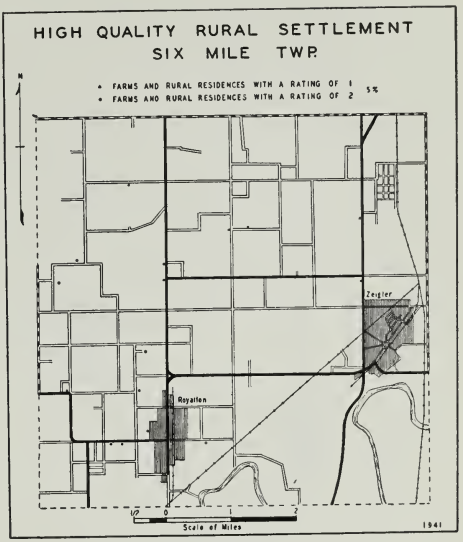

Fig. 4.

to 60 acres is approximately the average size of farms. Fig. 3 shows the rural settlement pattern of one of these townships. In this example, a fairly dense pattern is observed, particularly along the paved roads, although this township is the one having the least number of rural residences of the three. Most of the urban agglomerations have well developed urban-rural ecotones spread along the paved roads near their borders.

Any area so wholly dominated by one type of occupation must exhibit uniform qualities in its entire social and economic position. This fact is strikingly illustrated in this mining district. Unfortunately this uniformity conforms to a very low economic level. One of the best indicators of this regional poverty at the present time is the incidence of welfare relief. Williamson and Franklin counties are the two most important coal mining counties in Illinois. According to the January, 1941 report of the Illinois Emergency Relief Commission, 44.4% of the people in Williamson County, and 35% of those in Franklin County were dependent upon welfare relief of some kind. The figure for Williamson County was the highest in the state.

In order to determine more precisely the distribution of low income families, and to make certain that this distribution was not concentrated in either the urban agglomerations or the rural districts, the writer undertook a quality rating survey of the rural districts in three townships and one of the smaller urban communities. Each rural residence was plotted on a base map, and was given a quality rating of 1 to 5; 1 representing highly superior farms and residences, and 5 the lowest quality. The ratings were not based upon regional averages, but upon experience in such rating surveys made in widely separated areas in the United States. The average rating No. 3 therefore, is more of a national norm than a regional norm. It is not merely a housing survey, since many additional factors besides quality of houses are taken into consideration. Figs. 4 and 5 show the distribution of the quality ratings in Six Mile Township, Franklin County. The maps are self explanatory, and indicate the low standard of living in the rural areas. Fig. 6 shows a series of patterns in one of the smaller urban agglomerations. Note the correlation between welfare relief and the low quality ratings; also the extremely high incidence of relief, despite the fact that this small population center has an operating mine near its border. Most of these smaller centers today are not so fortunate. They are in pitiful economic condition for many reasons, among which are the following:

(1) These centers had fewer mines, hence when many of the mines ceased operations, such towns were left with little or no income.

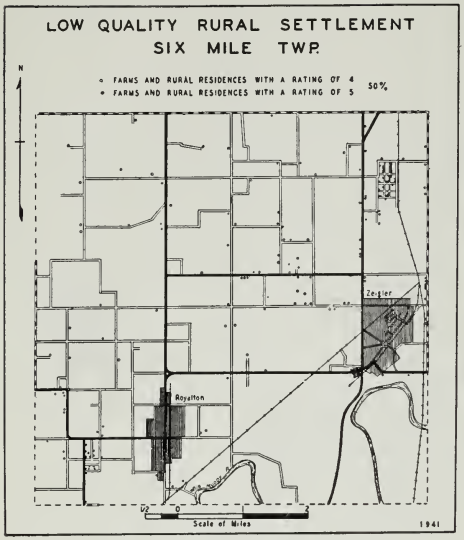

Fig. 5.

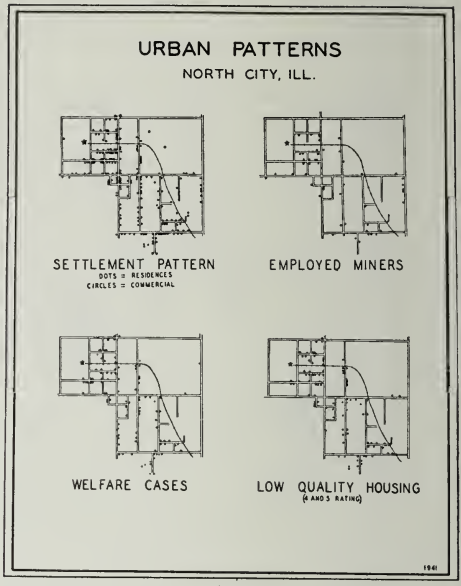

Fig. 6.

(2) Economic opportunities are less varied than in the larger centers.

(3) Welfare relief has tended to prevent migration.

(4) While the labor supply in this area is highly mobile, the residence of labor is extremely stable. In other words, while the miner is willing to drive as much as 20 to 30 miles to work he is hesitant to move his family from the home community. (This may be the result of mixed blood lines, or a characteristic communal feeling.)

The low standard of living over the area is almost entirely the result of economic conditions in the coal mining industry. The increased use of machinery in mining operations, the competition of other producing areas, the bad reputation of local labor organizations (in turn the result of prejudiced newspaper propaganda), and strip mine operations are among many factors contributing to the local industrial depression. Scattered throughout the area are the skeletons of mining enterprises: giant smokestacks rising solemnly from the rubble of crumbled surface buildings, or merely the insidious march of weeds up the flanks of an old rockpile.

The mines that are operating are either very large, or very small, and few of the larger mines are still in operation. It is a significant fact that each evening, local radio broadcasting stations in a half minute or so between commercial programs announce the 10 or 12 Franklin County mines that will be operating the following day. The small 'scavenger" mines are newcomers to this area, as in other large coal mining regions. They cater mostly to local consumption, and represent the pitifully futile attempts of the region to pull itself out of a hole by its own bootstraps.

This is only a brief summary of the needs of the area for a new regional income; the evidence is conclusive. Now let us examine the possibilities for such new income. While agricultural practices and marketing in the area can be greatly improved, the region will never become another Corn Belt, and the urban clusters will still remain. Manufacturing seems to be the principal hope. What then can the area offer in the way of manufacturing advantages? Most assuredly, they are many and varied, and most of them can be sumarized as follows:

(1) A large supply of semi-skilled labor.

(2) Cheap power—cheap enough to compete with any industrial area in the Middle West.

(3) A central location with respect to Mid-West markets.

(4) A wholly adequate network of transportation lines.

(5) An adequate water supply, now

that the Federal Government Crab Orchard project is nearing completion.

The industries best suited for the area probably belong to the chemical group, such as coal distillates, and cellulose derivatives. Powder plants for the national defense program fall under this category, and in recognition of this fact, the U. S. Army has placed the area in a first priority grouping in the program for future plant establishment. In peacetime these munitions plants could be fairly easily altered to produce such products as plastics or synthetic fibers.

The reputation received as the result of the Herrin strikes has been one of the most insidious factors preventing the influx of industry. The labor groups in Southern Illinois only want the chance to correct that reputation, and since that opportunity has not been offered by private industry, they are clamouring for Federal intervention.

Geographic factors of site and situation indicate that the abject poverty of the region is entirely unwarranted. The people of the area are praying that perhaps in a new type of service for their country, they may find a better and a happier future.

Papers in Geology

Extract From the Report of the Section Chairman

The Evanston program in Geology carried 25 papers, 13 of which are herewith published. The others were:

Behre, C. H., Jr., *Northwestern University, Evanston.*—Analagous structure in lead-zinc deposits of the Upper Mississippi Valley type.

Cohee, G. V., *State Geological Survey, Urbana.*—Trenton production in Illinois. (Being published by the Survey as *Illinois Petroleum No. 39.*)

Ekblaw, George E., *State Geological Survey, Urbana.*—Stages of Lake Chicago and development of the Great Lakes region.

Fisher, D. J., *University of Chicago, Chicago.*—Stereoscopic pairs projected in polarized light.

Fisher, R. F., *State Geological Survey, Urbana.*—Preglacial drainage of the Great Lakes region.

Bushman, E. F., *University of Illinois, Urbana.*—Insoluble residue studies of Middle and Upper Devonian limestone of southwestern Illinois.

Kesling, R. V., *University of Illinois, Urbana.*—Foraminiferal zoning of the Upper Cretaceous in western Alabama.

Osment, F. C., *University of Illinois, Urbana.*—Heavy mineral studies of the Selma, Ripley, and Prairie Bluff formations of western Alabama.

Parks, C. B. and G. W. Land, *State Geological Survey, Urbana.*—Fusain determination in coal by chemical analysis and microscopic count. (Being published in *Ind. Eng. Chem., Anal. Ed.*)

Schopf, *State Geological Survey, Urbana.*—Constituent plant particles in coal and their significance in the study of coal type variation.

Spotti, A. E. and J. N. Payne, *State Geological Survey, Urbana.*—Roof irregularities of Coal No. 6 in the Staunton-Gillespie region.

Sutton, A. H., *University of Illinois, Urbana.*—Age of the dolomite exposed at Momence, Illinois.

Maximum attendance was about 80. A. H. Sutton, University of Illinois, Urbana, was elected chairman of the Urbana meeting in 1942.

(Signed) Marvin Weller, *Chairman*

STRUCTURE CONTOUR MAP OF THE PRE-PENNSYLVANIAN SURFACE IN ILLINOIS*

MAURICE H. SMITH
State Geological Survey, Urbana, Illinois

Uplift, warping, and peneplanation of the surface previous to the deposition of Pennsylvanian sediments in Illinois caused truncation of the Mississippian, Devonian, Silurian, and upper and middle Ordovician systems on the margins of the basin and truncation of local structures. The pre-Pennsylvanian surface was not reduced to a flat peneplain. In places features of local erosional relief are evident. In the Beardstown area, western Illinois, a pre-Pennsylvanian hill stands about 50 feet high with four Pennsylvanian cyclothems wedging out on its flanks on or against the Salem and St. Louis formations of the Mississippian system. It is difficult to locate these erosional features merely from subsurface information, but geologic conditions in the outcrop areas indicate that isolated shallow basins were first filled with Pennsylvanian sediments which later accumulated to such a depth that they covered the hills leaving a flattish surface.

The LaSalle anticline (Fig. 1) extends in a northwest-southeast direction for more than 250 miles, from northern Illinois north of the Pennsylvanian boundary to the Indiana border of northern Wabash County in southeastern Illinois. This structure in northern Illinois is a very asymmetrical anticline with a west flank dipping more than 25° in pre-Pennsylvanian rocks and an east flank dipping less than 1°. South of LaSalle County, the structure is imperfectly outlined in Livingston and McLean counties due to lack of drill data. It is better known in Champaign, Douglas, Coles, Clark, Crawford, Lawrence, and Wabash counties where it has been extensively tested by drilling for oil and gas. In this southern portion it is asymmetrical, as in northern Illinois, but generally has a somewhat less steep western flank.

Along the Illinois River near LaSalle, the minimum differential uplift along the anticline was 900 feet, near Tuscola in Douglas County it is about 1400 feet, in Lawrence County about 400 feet and in Wabash County only 250 feet. This suggests a maximum movement near Tuscola with a gradual dying out of the structure in each direction. The area of maximum deformation moved progressively southward from the LaSalle area, with the maximum differential elevation in pre-Pennsylvanian times occurring in Douglas County, and, after Pennsylvanian deposition had begun, in Lawrence and Wabash counties.

The most notable structure in the area east of the LaSalle anticline is the Oakland anticline[1] which trends nearly north and south through Champaign, Vermilion, Douglas, Coles and Clark counties and a synclinal basin between this anticline and the Indiana line, also with a north-south trend. The east flank of the Oakland anticline appears to be somewhat steeper than the west. The structural relief is between 600 and 700 feet in southwestern Edgar County. Two eastward-pitching noses extend from the Oakland anticline toward the syncline in Edgar County. A narrow anticlinal fold trending northeast-southwest is shown in northeastern Clark County terminating the syncline at its southern end. The Oakland anticline intersects the trend of the LaSalle anticline near Casey, Clark County.

The western portion of the Illinois basin is characterized by a gentle eastward dip toward the basin amounting to 5 to 20 feet per mile. Just west of the Pennsylvanian margin are situated the Media, Warsaw, Colmar-Plymouth, Pittsfield-Hadley, Cap Au Gres, Valmeyer, and Dupo-Waterloo structures which influence the trend of the Pennsylvanian boundary but are not well shown by the structure contour map. A weak anticlinal zone extends from central Henry County southeast across northeast Knox, Stark and Peoria counties, dying out in central

* Published with permission of the Chief, State Geological Survey.
[1] Mylius, L. A., Oil and Gas Development and Possibilities in East-Central Illinois, Maps and Tables of Well Data: Ill. State Geol. Survey, Bull. 54, plate 21, 1927.

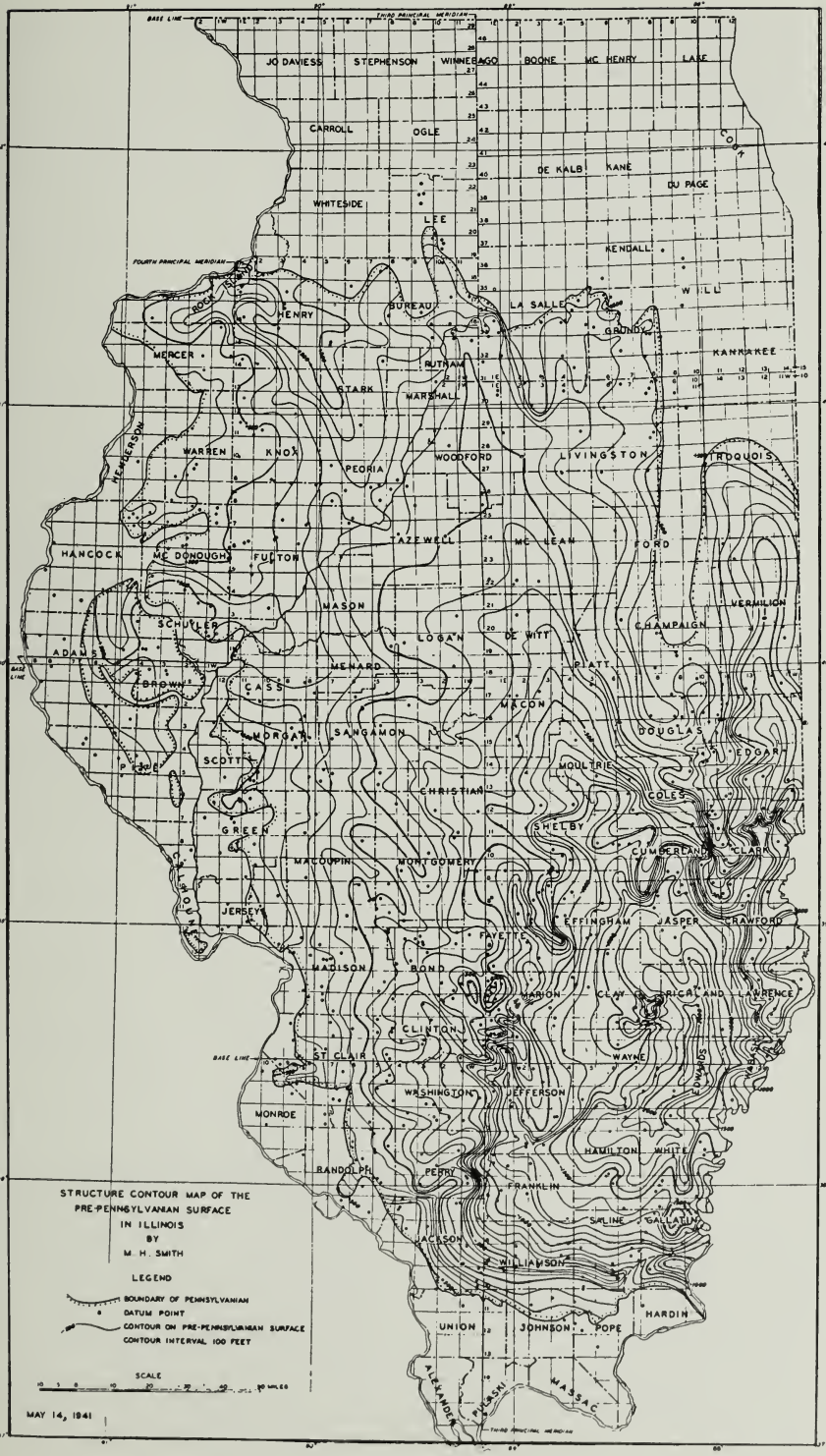
JO DAVIESS
STEPHENSON
WINNEBAGO
BOONE
MC HENRY
LAKE
CARROLL
OGLE
DE KALB
KANE
DU PAGE
WHITESIDE
LEE
KENDALL
WILL
HENRY
BUREAU
LA SALLE
GRUNDY
KANKAKEE
MERCER
STARK
PUTNAM
MARSHALL
HENDERSON
WARREN
KNOX
PEORIA
WOODFORD
LIVINGSTON
IROQUOIS
HANCOCK
MC DONOUGH
FULTON
TAZEWELL
MC LEAN
FORD
VERMILION
MASON
SCHUYLER
LOGAN
DE WITT
CHAMPAIGN
ADAMS
MENARD
PIATT
BROWN
CASS
MACON
MORGAN
SANGAMON
DOUGLAS
EDGAR
PIKE
SCOTT
MOULTRIE
CHRISTIAN
COLES
GREENE
SHELBY
CUMBERLAND
CLARK
MACOUPIN
MONTGOMERY
JERSEY
EFFINGHAM
JASPER
CRAWFORD
FAYETTE
MADISON
BOND
MARION
CLAY
RICHLAND
LAWRENCE
CLINTON
ST CLAIR
WAYNE
WASHINGTON
JEFFERSON
MONROE
HAMILTON
WHITE
RANDOLPH
PERRY
FRANKLIN
SALINE
GALLATIN
JACKSON
WILLIAMSON
HARDIN
UNION
JOHNSON
POPE
ALEXANDER
PULASKI
MASSAC
STRUCTURE CONTOUR MAP OF THE PRE-PENNSYLVANIAN SURFACE IN ILLINOIS
BY
M. M. SMITH
LEGEND
BOUNDARY OF PENNSYLVANIAN
DATUM POINT
CONTOUR ON PRE-PENNSYLVANIAN SURFACE
CONTOUR INTERVAL 100 FEET
SCALE
MAY 14, 1941

FIG. 1.

Tazewell County. An eastward-pitching anticlinal zone extends from Mason County eastward across Cass, Menard, Logan and northern Sangamon counties dying out in DeWitt and Macon counties. A shorter southeast-pitching anticline extends from northern Macoupin County across southeast Montgomery, and northern Bond County, dying out in southwestern Fayette County corresponding with the Sorento structure.[2] A little farther south another parallel structure extends from western Bond County southeast to Centralia. An eastward pitching anticline extends across southern Clinton County including the Bartelso and Hoffman oil structures. An anticline pitching slightly north of east extends from northern Randolph County across southern Washington County including the Nashville oil pool. The Ava-Campbell Hill anticline[3] pitches a little north of east across northern Jackson and southern Perry counties.

The deeper part of the basin is separated from the structurally flatter area of western Illinois just described, by a markedly asymmetrical anticline with a nearly north-south trend extending from southern Fayette or northern Marion County southward across Marion County through the Patoka, Sandoval, and Centralia oil fields and western Jefferson and eastern Perry counties. It has been named the DuQuoin anticline from a town of that name in southeastern Perry County. It has been considered a monoclinal flexure by some geologists because of the very slight westward dip from its crest. Although somewhat interrupted by eastward pitching anticlines and synclines, the east flank of the fold has structural relief of 500 or 600 feet with a general eastward dip amounting to as much as 100 feet per mile.

The DuQuoin anticline also has a marked effect on the westward thinning of the Pennsylvania system,[4] especially in Perry and Washington counties. This indicates that movement along the fold occurred during Pennsylvanian sedimentation. The Illinois basin extends eastward from the edge of the DuQuoin anticline with the lower portion filled with Caseyville and Tradewater sediments. The pre-Pennsylvanian surface originally consisted of an upland area in the west half and a basin in the east half of the region and the DuQuoin anticline represents the western margin of the basin. After the filling of this basin by Caseyville and lower Tradewater sediments, the strand line moved westward with general extension of the basin, the upper Tradewater and Carbondale formations were deposited in the broader basin to the west.

The most complicated structures in the Eastern Interior basin occur along its southern border. These include the Alto Pass fault zone trending northwest-southeast in Jackson and Union counties, which determines the southwest boundary of the Pennsylvanian area, and the Rough Creek-Shawneetown zone which enters Illinois at Shawneetown, Gallatin County, and extends directly west about 15 miles in Gold, Wildcat, and Cave hills, then turns sharply southwestward through Saline and Pope counties extending beyond the border of the Pennsylvania about 20 miles before disappearing beneath the Cretaceous sediments of the embayment area. South of the east-west segment of this fault is the deep eastward pitching Eagle Valley syncline in southern Gallatin County which extends eastward into Kentucky to form a basin nearly as deep as that in Edward and adjacent counties, Illinois. South of this basin is the Hicks Dome uplift with nearly 4000 feet of structural relief.

The map accompanying this paper shows only the broader general features of this complex area. There are no important differences in thickness or composition of the Pennsylvanian section in several fault blocks of this region, indicating that the structures are largely post-Pennsylvanian in age.

The deeper part of the basin in Shelby, Effingham, Cumberland, Jasper, Crawford, Lawrence, Wabash, Richland, Clay, Marion, Jefferson, Wayne, Edwards, White, Hamilton, and Franklin counties is bounded on the south by a monoclinal slope with dip of as much as 200 feet per mile associated with the Rough Creek-Shawneetown fault zone and other structures. On the west it is bounded by the

[2] Bell, Alfred H., The Sorento Dome: Ill. State Geol. Survey, Ill. Pet. No. 6, Fig. 2, sec. 4, 1926.
[3] Root, T. V., The Oil and Gas Resources of the Ava-Campbell Hill Area, Ill. State Geol. Survey: Rept. Inv. No. 16, Fig. 2, 1928.
[4] Henbest, L. G., Pre-Pennsylvanian Surface West of the DuQuoin Anticline. Trans. Ill. Acad. of Sci., 20, pp. 265-68, 1927.

steep east flank of the DuQuoin anticline, and on the north, from Cumberland County to Wabash County, by the steep west flank of the LaSalle anticline. Between Wabash and Gallatin counties, the deeper part of the basin extends beyond Illinois into southwest Indiana and western Kentucky. The structural relief of the basin from the base of the various surrounding slopes to its deepest part is 1000 feet to 1100 feet. The average dip is 10 to 50 feet per mile toward the deepest part of the basin, which consists of a narrow trough trending south across central Richland and western Edwards counties curving southwest across eastern Wayne County to northern Hamilton and White counties. Recent intensive drilling in this region has disclosed several anticlinal or domal structures within the deeper part of the basin or as pitching anticlines extending out into the basin from its flanks. Among these are the Loudon structure in Fayette County near the northwest margin of the basin;[5] the Salem structure, in Marion County[6]; a southeast-dipping monocline extending northeast in Jefferson County to southwestern Wayne County; an anticline trending northeast across southern Hamilton County and including the Hoodville oil field; an anticline extending northeast from northwest Gallatin County across central White County, including the Omaha oil structure; an anticline trending north in eastern White County, including the New Haven, Stroms, and Calvin oil structures; two westward pitching anticlines in Wabash County including the Keensburg and Mt. Carmel oil structures; an anticline pitching south in west-central Cumberland and northwest Jasper counties; and a southwest pitching anticline in southwest Coles and eastern Shelby counties. Within the deeper part of the basin a prominent domal structure in southeast Clay and northern Wayne counties includes the Clay City oil structure. The anticlines around the borders of the deeper part of the basin tend to pitch toward the basin from all margins. The total relief from the center of the basin in Richland, Wayne, and Edwards counties to the margin of the Pennsylvanian sediments in western Illinois is near 2000 feet.

The writer is grateful to Dr. H. R. Wanless, of the University of Illinois, and Mr. L. E. Workman of the State Geological Survey for helpful suggestions and criticisms in the preparation of the manuscript.

[5] Randall, D. C., Geology and Development of the Loudon Pool, Fayette County, Illinois: 25th Annual Meeting of the A.A.P.G., p. 16, 1940.

[6] Arnold, H. H., Jr., Salem Oil Field Marion County, Illinois: Bull., A.A.P.G., Vol. 23, p. 1352-73, Figs. 4. 5, and 6, 1939.

DEVONIAN FORMATIONS IN NEW MEXICO

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Until 1941 it has generally been considered that only one Devonian formation was present in the state of New Mexico. The writer during the past five years has definitely established the occurrence of three Devonian formations, one of middle and two of upper Devonian age. There is a possibility of an existing fourth Devonian formation, but sufficient evidence for establishing this conclusion has not yet been obtained. The Canutillo formation, limited to the Franklin Mountains, Texas, does not extend into New Mexico. This formation has been designated by other workers as being middle Devonian in age and shows no relationship to middle Devonian sediments in New Mexico. The Sly Gap formation crops out in the Sierra Caballo, San Andres, and Sacramento mountains. The Sly Gap is tentatively correlated with the Hackberry of Iowa, with some affinities with the Snyder Creek formation of Missouri, and bears definite relationship to the Martin limestone of Arizona, and the Devils Gate formation of Nevada. Overlying the Sly Gap formation is the Percha shale, which has long been established as being correlative with the Ouray limestone in Colorado and in Arizona. This formation crops out only in the southwestern portion of New Mexico, west of the Rio Grande, whereas the Canutillo formation and the Sly Gap are found only east of the Rio Grande. There is no known section in which the actual stratigraphic relationship of the Sly Gap and the Percha shale is shown.

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NIAGARAN OSTRACODS FROM BURLINGTON, WISCONSIN

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Introduction.—The Niagaran ostracods reported were discovered in the insoluble residues in connection with a sedimentary study of the rock succession exposed in the quarry at Burlington, Wisconsin. At the Illinois State Academy of Science Annual Meeting held at Galesburg, May, 1940, Dr. J. R. Ball presented a paper on the Burlington quarry.[1] In his article he describes the location of the quarry, lithology, fauna, and other characteristics of the strata. In brief, the quarry is located one mile west of Burlington along state highway 11; the rocks are extremely well-bedded, argillaceous dolomites which are mottled greenish gray and deep red. Mr. L. E. Workman refers this section to the lower part of the Joliet formation which he considers to be equivalent to the Osgood. Several years ago when the quarry workings were at a level now covered by water, the rocks of this lower part consisted of fairly thick-bedded dolomite of solid deep maroon color containing concretion-like masses of spongy, maroon rock.

Method of Obtaining Residue.—A solution of hydrochloric acid diluted 9 parts of water to 1 part of concentrated acid was used to obtain the residues. It was found that this strong concentration gave more satisfactory results with regard to the extraction of the ostracods than the use of a very dilute acid solution applied over a relatively long period of time. With the latter method the specimens came out with frayed margins despite the precautions taken in handling. Furthermore, the formation of fine particles which coated the other grains caused a retardation in the activity of the process due to the lack of penetration of the weak acid.

Character of Residue.—The percentage of residue ranges from about 10% to 45% of which only a fraction of one per cent is greater than 200 mesh. The very high amount of material less than 200 mesh consisting chiefly of clay and silt suggests the argillaceous character of the rock. The staining technique of adding potassium ferrocyanide [$K_4FE(CN)_6$] to an acid solution (HCl) in which the rock sample is immersed, yields a solid, deep, blue stain except for the calcitic vugs. This indicates the dolomitic character of the rock. The material greater than 200 mesh is mainly secondary silica. A graphical analysis of the quantity of insoluble material indicates a very irregular vertical distribution. This is typical of the lower part of the Joliet formation thus confirming Mr. Workman's correlation.[2]

The fauna of the residues includes the following: arenaceous foraminifera which seem to be abundant throughout most of the section, internal molds of small brachiopods, fragments of small gastropods, abundant bryozoa remains, a few hexaxial sponge spicules, and an abundant ostracod fauna. The ostracod fauna is an interesting one. The specimens obtained are preserved as internal molds of siliceous filling, hence their presence in the residues. Of course, these specimens exhibit the internal characters of the animal's shell. An attempt was made to determine whether the external characters are preserved anywhere in the rock. Samples of rock were crushed and sieved. Each grade size was separated, washed, and examined. Surprisingly enough there was very little or practically no suggestion of a microfauna. It seems very doubtful whether the external characters exist in the present rocks. Along certain zones of fine mottling, there is an abundance of ostracod material.

Ostracod Fauna.—There is quite a diversity of forms represented by approximately 15 species which includes 9 or 10 genera. Most of the internal characteristics are clear except in a few cases where overlap is difficult to determine. Although the complete identification of the fauna has not yet been made due to

[1] Ball, J. R., Typical Lower Mississippi Valley Silurian Lithology in Southeastern Wisconsin, Trans. of the Ill. Acad. Sci., Vol. 33, No. 2, Dec., 1940, pp. 152-154.

[2] Workman, L. E., Contributions to Correlations of Silurian Systems in Northeastern Illinois through Study of Insoluble Residues: Bull. G. S. A., Vol. 50, No. 12, Part 2, p. 2015, 1939. (Abstract.)

the fact that many of these are new forms, a few of the genera represented are: Kloedenella, Tubulibairdia, Leperditia, and Bairdia.

Some of the forms are highly ornamented. One of them is a clear example of dimorphism. The female has two large, bulbous, brood pouches posteroventral. There are perforations along the line of juncture between the brood pouch and the main part of the shell. These brood pouches become detached from the animal and are found separate. It is common to find that the brood pouches are much more abundant in the residues than entire individual specimens. Where perhaps 5 or 6 entire specimens could be found, it is possible to find 50 to 100 brood pouches. The male has the general shape and characters similar to the female without the swellings.

Among the other types are those that contain smooth surface shells.

Conclusions.—Many of the workers on the Silurian rocks of the Middle West such as Workman, Ball, Dunn, Edwards, Priddy, and others have pursued different lines of attack in order to get a better understanding of the correlation of the rocks of this system. Lithological studies, insoluble residues, mineralogical studies, foraminifera[3] and other fossil forms have been used in the attempt. Dr. P. H. Dunn has completed a study of the arenaceous foraminifera of the Silurian rocks of several of the midwestern states. This is in the process of publication.[4] He has indicated that ostracods are abundant in many of the samples he has used for the extraction of foraminifera. The study of the ostracods, their diversity and distribution might supplement other methods. Ulrich and Bassler have done a classical piece of work in using ostracods to correlate the Silurian rocks of Maryland[5] and adjacent states. Perhaps that same approach can be used in the Middle West. The foraminiferal zones will be established by Dunn; the ostracods might lend themselves to the same analysis.

Finally the fossil forms and the high content of argillaceous material suggest proximity to shore line conditions of sedimentation. Cumings and Shrock have indicated this in their paleogeographic map.[6]

[3] Dunn, P. H., Microfaunal Technique in the Study of Older Paleozoic, Trans. of the Ill. Acad. Sci., Vol. 25, No. 4, June, 1933, pp. 140-141.

[4] Dunn, P. H., personal communication.

[5] Ulrich, E. O. and Bassler, R., Paleozoic Ostracoda: Their Morphology, Classification, and Occurrence, Maryland Geol. Survey, Silurian, 1923.

[6] Cumings, E. R. and Shrock, R. R., The Geology of the Silurian Rocks of Northern Indiana, The Dept. of Conservation State of Indiana, Publication No. 75, 1928, p. 165.

THE CHEMISTRY OF LEAD-ZINC DEPOSITION AND THE PROBLEM OF ZONING

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ABSTRACT

The problem of the relative positions of galena and sphalerite (Pbs and ZnS) in the "Mississippi Valley" and other types of lead-zinc deposits is attacked from the point of view of a magmatic origin. Evidence has been generally cited to show that, on the basis of solubility determinations, sphalerite should occur nearer the surface and later paragenetically than galena. The reverse order holds in nature.

Arguments based upon available data show that this unexplained order of deposition is probably due to (1) supersaturation phenomena, or (2) the formation of complexes.

Detailed experimental work, subjected to careful chemical control, shows that neutral chlorides are effective in forming complexes with lead; thus increasing its solubility. At the conditions of deposition of the Mississippi Valley deposits (ca. 100° C. and 60 at.) 2.0 normal $CaCl_2$ would be effective in producing the observed mineral relations. This concentration is in accord with that found by Newhouse in fluid inclusions in the galena. It appears probable that the solutions were relatively concentrated yet generally neutral in composition.

A NEW EDRIOASTER FROM THE UPPER ORDOVICIAN OF NORTHERN ILLINOIS

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An excellently preserved specimen of an edrioaster was collected by the writer from a shale seam in a small limestone quarry one and one-half miles east of Garden Prairie, McHenry County, Illinois. A considerable brachiopod and bryozoan faunule is associated with the specimen, but the bryozoan specimens lack internal structure. M. E. Chappars of Walker Museum, University of Chicago, has been kind enough to examine the associated fauna and he has established the age as Middle Richmond (Liberty-Whitewater).

The edrioaster belongs to that rare group of Edrioasteroidea in which all the ambulacra curve in the same direction. In the genera *Lebetodiscus* and *Ulrichidiscus* all ambulacra curve to the left, in *Cooperidiscus* and *Foerstediscus* all curve to the right. The ambulacra of the present specimen curve to the right and the interambulacral plates are arranged in mosaic as in *Foerstediscus*, rather than in imbricate pattern as in *Cooperidiscus*.

The genus *Foerstediscus* was established by Bassler in 1935 upon the species *F. grandis* Bassler from the Trenton of Woodford County, Kentucky. Two additional species were described by Bassler in 1936, *F. splendens* from the Decorah at St. Paul, Minnesota, and *F. parvus* from the Hull formation (Trenton) of Kirkfield, Ontario. The present specimen is distinguished from these species by its wider and less prominent ambulacra and by its narrower disc of attachment.

The particular value of the McHenry County specimen lies in the fact that the aboral surface and part of the interior of the theca are preserved. The aboral side of *Foerstediscus* has not been described. The frame consists of an outer row of small plates and an inner row of much larger plates which form an even border to the large tegmental area. The mouth is surrounded on the interior of the theca by five prominent plates, similar in appearance to the perignathic girdle of some echinoids. This circumoral ring is here recognized for the first time. Bather figured edrioaster specimens which exhibit five lobes on the inner part of the tegmen, but this is an entirely different structure.

R. E. Bassler has seen the specimen and has advised the writer concerning its structure and affinities. The specimen will be deposited in the United States National Museum.

THE SEDIMENTOLOGY AND PHYSIOGRAPHY OF WISCONSIN GLACIAL OUTWASH ALONG THE CHIPPEWA RIVER

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The Chippewa River flows across Wisconsin in a southwesterly direction to empty into the Mississippi at Lake Pepin. During the Wisconsin glacial epoch the Chippewa ice lobe occupied the upper part of the Chippewa valley. Meltwater from the ice built a large outwash plain in front of the terminal moraine. Downstream, this outwash grades into a valley train along the Chippewa River and extends all the way to the Mississippi River. The melt water carried so much sediment that a deltaic fan was built in the Mississippi Valley, damming the river to form the predecessor of Lake Pepin.

The Chippewa River at that time was overloaded, depositing sediments instead of eroding them as it is doing today. Like present day aggrading streams, it occupied a number of small, anastomosing channels, traces of which still persist. Aerial photographs of a large remnant of the glacial flood plain southwest of Durand show a network of dark bands that mark the position of the former stream channels. They are not shown by the topographic map and even field examination failed to disclose them.

After the recession of the glacial margin the overloading of the Chippewa River ceased. Deposition gave way to erosion. The river became one single meandering stream which cut its modern valley to a depth of from eighty to one hundred feet below the level of the glacial flood plain, and formed a complicated series of lower terraces.

Since the glacial deposits along this valley offer a complete gradation from glacial till to the aqueous sediments of the outwash plain and the valley train, they were deemed worthy of a sedimentary study. Channel samples were taken at approximately five mile intervals for the sixty mile distance along the valley. Most of the samples were taken at road cuts because they offered the best exposures.

The results of the size analysis of these samples are given in the table below.

The average size shows a marked increase with the change from till to outwash and from there on it decreases with fluctuations. The initial increase is best explained by the selective action of running water; the tendency to deposit the coarser portions of the load and carry the finer ones on. The successive decrease in size of the particles may be explained by continued selective transportation. The lack of marked rounding of the fragments indicates that abrasion was not important. The standard deviation, or "spread" of the size range, shows a continual decrease downstream. Evidently the longer the water worked on the sediments, the better sorted they became.

Sample	Outwash										
	Till	1	2	3	4	5	6	7	8	9	10
Geometric mean size in mm.	.21	3.11	1.54	1.05	1.04	.44	.95	.65	.37	.44	.43
Standard deviation in Wentworth grade units	4.18	2.66	2.57	2.42	2.24	1.09	1.81	1.67	.71	.74	.67

Other properties of these sediments, such as shape, orientation, and composition, will be studied quantitatively in the future. At present it is safe to say that the sediments and their environment of deposition have had a marked effect upon each other. The properties of the sediments change progressively downstream; the physiography was altered wherever they were deposited.

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ADDITIONAL EVIDENCE ON THE ORIGIN OF CONODONTS

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Samples collected near LaSalle, Illinois, from black shales of Pennsylvanian McLeansboro age have yielded, in addition to an associated fauna of *Lingula, Orbiculoidea,* and fragmentary vertebrate remains, a number of excellent conodont assemblages.

Study shows that without doubt a typical assemblage consists of an anterior pair of Polygnathids, a pair of Bryantodids, and a posterior group of several pairs of Hindeodellids, arranged in a linear series. In addition to this relatively common type, one specimen shows the presence of three Polygnathids, and two others, the presence of individuals belonging to the "genera" *Distacodus, Lonchodina,* and *Hibbardella* or *Euprioniodina.*

The evidence afforded by the assemblages regarding the zoological affinities of the conodonts is not wholly positive. From their general aspect it seems unlikely that they are representatives of any known group of vertebrates, and equally improbable that they represent the radular teeth of gastropods or cephalopods. Rather they seem to be a part of the pharyngeal aparatus of some Paleozoic annelid.

The group is apparently not homogeneous. This is attested to by the fact that one of the many assemblages possesses three Polygnathids, and two other assemblages posess teeth of a radically different nature.

The taxonomic problem raised is one of no mean dimensions. Inasmuch as a system of taxonomy should be so constructed as to represent the evolutionary relationships of the animals involved, and because the evidence presented in this material shows that structures which have been referred to different families may in reality belong to the same individual, considerable revision of the taxonomic treatment of the group seems necessary. To correct the present terminology by orthodox means would be extremely difficult and would require years to execute.

The solution which seems most feasible is the complete transfer of the present nomenclature to the "Ordo militaris" advocated by Carey Croneis for use in just such cases. This scheme would remove the necessity of a complete revision of the present classification, would allow the further study of conodonts as tools for the stratigrapher, and, at the same time, would permit the separate development of another classification based upon biological relationships.

A SHAPE-ROUNDNESS STUDY OF BEACH SANDS FROM CEDAR POINT, OHIO

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ABSTRACT

Seven samples of beach sand, collected at one mile intervals from Cedar Point spit built across Sandusky Bay, Lake Erie, were treated with acid, sieved, and split into "lights" and "heavies" by means of acetylene tetrabromide.

The "lights", mainly quartz, from each sieve separate, were mounted and projected, and shape (sphericity) and roundness determinations were made. It was statistically observed that the roundness showed a definite decrease in the direction of transport. Sphericity values of the grains decreased also, but much less markedly.

The decreases in roundness and sphericity do not appear to be due to abrasion but either to a selective sorting by the littoral currents or to some cracking or splitting of grains during transport. Many of the finer grade separates do show evidence of fracturing.

USE OF STEREOSCOPE WITH AERIAL PHOTOS IN ELEMENTARY GEOLOGY

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Recently the Department of Geology at the University of Chicago has adopted the study of aerial photographs by means of the stereoscope as an aid to the study of topographic maps in beginning geology classes. Aerial photographs are being employed more and more by the governmental surveys and private companies, and it is well that future geologists become familiar with them early in their careers.

The photos are taken looking vertically downward, with a single lens camera. Contact prints made from the negatives are 7x9 inches or 9x9 inches, and have a scale of approximately 1:20,000 or about three inches to the mile. Consecutive photos overlap about sixty percent, making them well adapted for use under the stereoscope.

The great advantage of viewing the photographs through a stereoscope lies in the fact that the features on the photo are made to appear as a three-dimensional or spacial model. This is helpful to students who are using topographic maps for the first time. By using topographic maps and aerial photos together, he can soon learn the meaning of contours and be able to read them critically.

A method of teaching the significance of contour lines is to introduce an exercise whereby the student makes a contour map from a stereoscopic pair of aerial photographs. Select a pair of photos that show well developed valleys and rounded hillsides with relief not over two hundred feet. Using drafting tape, fasten a clear piece of celluloid on one of the photos over the area that is to be mapped. Mark elevations of various points in ink on the celluloid, not over a half mile apart. Place the two photographs under the stereoscope and adjust them in fusion to suit the eyes. While viewing the photos through the stereoscope, draw in the contours with a wax pencil on the celluloid at their adjudged elevations along the hillsides.

Physiographic forms are well shown on aerial photos, but are much more impressive when viewed through a stereoscope. Such forms as dunes, drumlins, moraines, sinkholes, etc. are illustrated on topographic maps, but the beginning student can gain little or no idea as to how they actually appear in the field from the map alone. This difficulty is easily solved by stereoscopic observation of aerial photographs. Relative sizes of the different features are conveyed to the student through comparison to houses, trees, or other familiar objects present in nearly every photograph.

By the use of topographic maps and aerial photos together many problems in structural geology can be worked out in the laboratory. Where conditions are favorable, outcrops can be seen on the photos and the direction of dip of the beds detected. However, it must be remembered that slopes of hills and beds are in general, greatly exaggerated. Faults are often visible where none would be suspected from a study of the topographic sheet. Through the use of both topographic maps and aerial photos the student becomes aware of the underlying structural control which is responsible for many physiographic features.

No list of selected aerial photographs suitable for stereoscopic study of geologic features has been compiled. An attempt is now being made at the University of Chicago to make such a list, and it is hoped that a preliminary report may be ready soon.

The cost of supplying a laboratory with an adequate number of stereoscopes and aerial photographs need not be great. Photographs can be purchased from the Department of Agriculture for twenty cents per print when ordered in lots of one hundred or more, or twenty-five cents per print when ordered in smaller quantities. The Department of Agriculture is the only national governmental agency authorized to sell aerial photographs. It

publishes and distributes, free of charge, a monthly index map of the United States which shows the extent of aerial photography completed or in the process of completion. This map does not include areas photographed by agencies other than the Department of Agriculture.

Commercial stereoscopes suitable for study of aerial photographs sell for thirty-three dollars and more. However, a simple stereoscope constructed from four small mirrors and other readily available material, costing about a dollar, can be made as follows:

The frame is made of ½ inch lumber screwed together, and mounted on legs of ½x¼x⅛ inch channel iron. Each leg is held by two studs screwed into a ⅛x¾ inch strap-iron strip fastened to the end surfaces of the frame. (See fig. A) Extra holes may be drilled in the legs to make the height adjustable. The top of the frame is covered with sheet tin in which are cut eye holes 1½ inches in diameter on 2½ inch centers, and a triangular hole for the nose. (See fig. A.)

All of the mirrors are inclined 45 degrees as shown in fig. C. The two inner mirrors measure 2x2 inches and are placed with the centers of their reflecting surfaces 2½ inches apart (E-E', fig. C). To allow room for the nose, a corner is cut from each of the inner mirrors as in fig. D, and from the inside edges of the wooden frame holding them. The two outer mirrors are 4x5 inches and placed with the long dimension horizontal. Their reflecting surfaces are 3½ inches, measured horizontally, from the reflecting surfaces of the inner pair. The tops of the outer mirrors are ¾ of an inch vertically above the tops of the inner mirrors. Each mirror is held in place by small copper cleats. Light is provided by two 110 volt bulbs with C-7 candelabra bases. Each is in a bakelite combination plug having a switch and a shade. The plugs are held in a double wall socket mounted under the two inner mirrors. To shut out extraneous light, tin flaps 7x2¾ inches are hung by small hinges at each end of the stereoscope (fig. C). Dull black enamel is used for the finish.

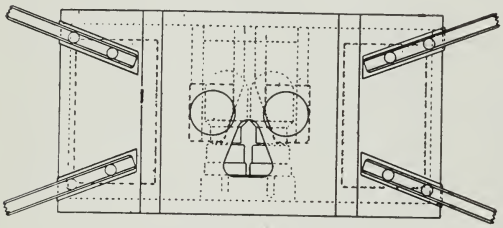

FIGURE A TOP

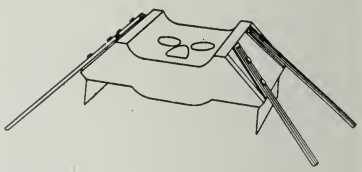

FIGURE B PERSPECTIVE

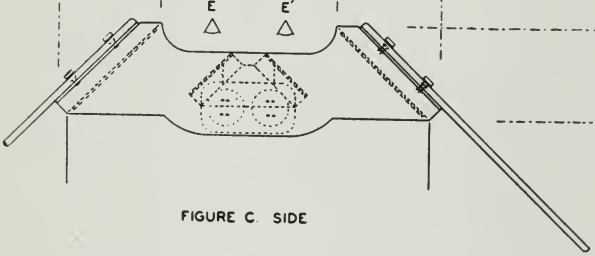

FIGURE C SIDE

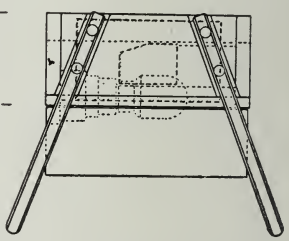

FIGURE D END

6 INCHES

STEREOSCOPE FOR VIEWING AERIAL PHOTOGRAPHS

THE APPLICATION OF PROBABILITY THEORY TO SEDIMENT SAMPLING

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ABSTRACT

The question of how large a sample should be collected to determine the average sphericity or roundness of a sedimentary deposit has long been unanswered. Tentative answers to this question have ranged from 50 pebbles or sand grains to 150. An attempt is made in this paper to develop a method of sampling which will answer this question from a rigorous mathematical standpoint.

The theory of sampling which is applied in this paper is based on the equation of the standard error of the mean. This equation states that the standard error of the mean of a sample is directly proportional to the standard error of any one observation and inversely proportional to the square root of the number of observations in the sample. From this fundamental expression, it is shown that the number of sedimentary particles required to obtain a tolerated per cent error of the mean of a sample is dependent on two quantities, (a) the true average or mean of the sampled population, and (b) the spread or standard deviation of the population's frequency distribution. The foregoing relations are only true if the sphericity and roundness distributions of the population follow the bell-shaped distribution of a normal curve.

To test this prime requisite, 500 pebbles were collected at random from a glacial outwash deposit. The resulting frequency distributions of roundness and sphericity were found to be essentially normal. The choice of glacial outwash assured a large spread of the frequency distributions. This is desirable because results obtained from this type of deposit may now be applied to most other types of sediments. Fig. 1 is based on the equation for the standard error of the mean. It illustrates the inverse relationship between sample size and per cent error of the mean. A method of approximation, based on graphs similar to Fig. 1, has been devised by which the true mean of the sampled population is estimated. From this value the sample size is then determined for any tolerated error of the mean.

In general, a sample of 50 particles is more than adequate for roundness and sphericity determinations.

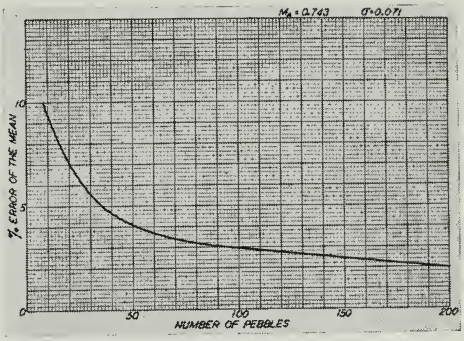

Fig. 1.—Graph illustrating the inverse relationship between sample size and per cent error of the mean.

MISSISSIPPIAN STRATIGRAPHY OF OHIO

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The Mississippian rocks of Ohio consist of six formations: Maxville limestone, Logan formation, Cuyahoga formation, Sunbury shale, Berea sandstone, Bedford shale.

The Bedford shale is a chocolate-brown, red and blue-black, argillaceous shale. It crops out along the western and northern margins of the Mississippian outcrop zone in Ohio. Its thickness varies from 40 to 110 feet. Only in the basal few feet are there fossil remains. A slight disconformity exists at the base of the Bedford. Nearly everywhere there is a sharp contact between it and the underlying Ohio shale, but rarely is there evidence of the existence of erosional conditions between the deposition of the Ohio shale and of the Bedford shale.

The Berea sandstone consists essentially of a light tan or light gray, well sorted, fine-grained sandstone or siltstone. In southern Ohio it is composed of several thin layers of siltstone, each layer from 8 to 15 inches thick. In central Ohio thin, argillaceous and arenaceous shale layers to a total thickness of about 7 feet occur near the base of the Berea. Above are fine-grained, rather massive sandstone layers, each 2 to 8 feet thick. In northern Ohio the maximum thickness of the Berea exceeds 200 feet.

The contact between the Berea and the underlying Bedford shale is marked by a well-defined erosional surface.

Overlying the Berea along the western margin of the Mississippian outcrop in Ohio is the Sunbury shale. This is a black, fissile, carbonaceous shale lithologically very similar to the Ohio shale. In northern Ohio the Sunbury shale is indistinguishable from the black shales of the Orangeville member of the Cuyahoga formation. Hence the Sunbury is not recognized as a distinct formation in this area, all of the black shales immediately overlying the Berea sandstone being included in the Orangeville member.

Seven lithologic facies, each subdivided into a varying number of members and submembers are recognized in the Cuyahoga formation:

Tinkers Creek shale facies
  Meadville shale member
  Sharpsville sandstone member
  Orangeville shale member
    Aurora sandstone submember

River Styx conglomerate facies
  Black Hand conglomerate member
  Armstrong sandstone member
    Rittman conglomerate submember

Killbuck shale facies
  Black Hand shale member
  Armstrong sandstone member
  Burbank member

Toboso conglomerate facies
  Black Hand conglomerate member
  Pleasant Valley member

Granville shale facies
  Black Hand siltstone member
  Raccoon shale member

Hocking Valley conglomerate facies
  Black Hand conglomerate member
  Fairfield sandstone member
  Lithopolis siltstone member

Henley shale facies
  Henley shale member

These facies have been named in progressive order from northeastern Ohio to south-central Ohio.

The axes of the conglomerate facies trend northwest-southeast. It is probable that the conglomerate facies represent deltas formed by deposition of coarse materials derived from lands to the southeast. Intervening shale facies are areas where fine sands, silts and clays accumulated.

The Logan formation directly overlies the Cuyahoga formation. From south central Ohio the Logan outcrops extend northward with varying thickness to Holmes and Wayne counties, where it thins rapidly due to erosional beveling.

Three lithologic facies are distinguished in the Logan formation:

Pretty Run sandstone facies
  Rushville shale member
  Vinton sandstone member

Allensville conglomerate member
Byer sandstone member
Berne conglomerate member

Scioto Valley shale facies
Vinton sandstone member
Portsmouth shale member
Buena Vista sandstone member

Vanceburg siltstone facies
Vinton sandstone member
Churn Creek member
Vanceburg siltstone member
Rarden shale member
Buena Vista sandstone member

The material composing these deposits was probably derived from the southeast.

The Maxville limestone overlies the Logan formation in southeastern Ohio. It is rarely exposed, being nearly everywhere covered by Pennsylvanian deposits which overlap on to the Logan formation.

THE OCCURRENCE OF COMMERCIAL MUSCOVITE IN PEGMATITES

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Descriptions of most mica-pegmatite districts are available, but due to a general lack of attention to precise description of mineral relationships, much of the earlier literature is of little significance. The purpose of this paper is to emphasize certain general truths which appear to govern the formation of large muscovite crystals of commercial value. Discussion will be limited to occurrences of the greatest economic importance; apparently most of the world's production of sheet mica has come from the Madras Presidency and the Province of Bihar and Orissa, India, and the states of North Carolina, New Hampshire, and South Dakota.

The development of the concept of replacement in metallic ore-bodies was followed by the concept of the replacement origin of many pegmatites. The principles of ore-body zoning around an intrusion is likewise paralleled by the zonal distribution of pegmatites, best established by Maurice[1] in the Spruce Pine district, North Carolina, on the basis of the composition of the plagioclase of the pegmatites. Close study of other pegmatite areas should reveal more instances of such zoning.

As a basis, the writer proposes to accept a modified two-stage, aqueo-igneous theory for the formation of pegmatites containing commercial sheet mica. It appears reasonable, as Landes[2] suggests, that the two stages, the first of primary introduction and the second of open system replacement by hydrothermal solutions, may be merely one long-continued stage, in which the components which modify the original mineralogy were derived directly from portions of the same pegmatite closer to the source. Replacement relations in pegmatites are often difficult to interpret, and without strict definition of terms the boundary between the minerals of the magmatic stage and those of the hydrothermal stage is indistinct.

Field relations and the literature show that commercial muscovite is apparently of late magmatic and early hydrothermal origin. Much of the evidence for late formation lies in the continuity of distribution of the mica books along country-rock contacts, along interior structural features, along seams, and in shoots wandering irregularly about in the pegmatite. The definite continuity for several hundred feet of commercial muscovite shoots in large pegmatites has been often observed. Two or more such mica shoots, of different colors and with distinct differences in perfection of crystallization, are occasionally met in the same pegmatite, indicating different times of formation.

Plagioclase feldspar and quartz are the two most persistent mineral associates of muscovite. From a compositional

[1] Maurice, C. S., The pegmatities of the Spruce Pine district, North Carolina: Econ. Geology, Vol. 35, pp. 49-78, 158- 185, 1940.
[2] Landes, K. K., The origin and classification of pegmatites: Am. Mineralogist, vol. 18, pp. 33-56, 95-103, 1933.

viewpoint, the three largest mica districts of the world yield the best and most mica from pegmatites containing plagioclase considerably more calcic than albite, with microcline absent or present only in small amount. Of the Kodarma district, the largest in India, Roy[3] writes, "Workable quantities of mica occur only in those pegmatites in which albite-oligoclase is the dominant or the only feldspar present." Of the Spruce Pine mica pegmatites, Maurice[4] says, "The predominating mineral is plagioclase, generally calcic-oligoclase." In the Nellore district, the second largest in India, Biswas[5] emphasizes the abundance of plagioclase ranging from albite to andesine. Oligoclase is present in the mica pegmatites of New Hampshire and South Dakota, but no correlations similar to the above have been drawn.

Perfection of crystallization in the muscovite crystals is of first importance commercially; much mica is inclined to crystallographic irregularities due either to post-pegmatite earth movement or to the influence of unfavorable conditions during formation. The principal crystallographic variety is the type known as "A" or "wedge" mica, in which the mica books are shaped much like an arrowhead, and commonly taper toward the point, sometimes as much as 30°. The literature contains references to this variety in every mica district in the country, and foreign references further show its frequent presence.

Hess[6] attributed the formation of A mica to "cooling and stoppage of solutions," and suggests that, with continued flow of solutions the A mica may recrystallize into clear, smooth books. From the large size, over three feet, reached by some A mica crystals, and from definite differences in occurrence between A and flat mica, the writer believes that continued flow of solutions merely makes the A books larger, and that, at lower temperature, coupled with other less definite factors, A mica is formed rather than flat.

Of the spatial relationships of muscovite shoots and pockets to the country rock contacts and internal structures no strong generalizations can be made, except that in many pegmatites the mica-rich portions lie along the country rock contacts and along the margins of barren quartz masses, if present. It is not unusual for the mica shoot to occur along the hanging wall alone, or to leave the contact and wander through the main pegmatite mass. In some bodies the mica occurs in segregation pockets of almost solid mica, but this type is rare. Of the continuity of mica shoots, Roy[7] describes an Indian mine which has been worked for 1000 feet along the strike and for 400 feet down dip; 700 to 800 feet is probably about the length of the longest shoots worked in North Carolina.

The source of the muscovite of pegmatites has been held in question. The frequent occurrences of mica pegmatites in the muscovite schists and gneisses of the pre-Cambrian and Paleozoic, coupled with the rarity of commercial mica in pegmatites in the source batholiths and in mica-free rocks, led several observers, such as Holland[8] and Smith[9] in India, to attribute the muscovite to recrystallization of material assimilated from the country rock by pegmatitic action. Even when the pegmatites occur in mica-poor country rock, they may at reasonable depth traverse micaceous formations. If the concept of the pegmatite as an open system is accepted, it should be possible for the pegmatitic liquor to assimilate any constituents of mica which might be lacking, later to precipitate the mica where conditions were favorable, no matter what the wall rock might be.

To oppose this view, several estimates of muscovite content of pegmatites by Mohr[10] show that the average mica mine yields only from 2.5 to 4% of mica by weight; block mica contents of 4 to 7% are not uncommon, but they characterize shoots especially rich in mica. Bearing in mind the nature of the pegmatite differentiation process, there appears to be

[3] Roy, S. K. Sharma, N. L., and Chattapodhyah, G. C., The mica-pegmatites of Kodarma, India: Geol. Mag., vol. 76, pp. 145-164, 1939.
[4] op. cit., p. 68.
[5] Biswas, S. L., Origin of the mica pegmatites of Nellore: Quart. Jour. Geol. Min. Met. Soc. India, vol. 7, pp. 135-147, 1935.
[6] Hess, F. L., The pegmatites of the western states: Ore deposits of the western states, (Lindgren volume), pp. 526-536, Am. Inst. Min. Met. Eng., 1933.
[7] op. cit., p. 151.
[8] Holland, T. H., Mica deposits of India: Mem. India Geol. Survey, vol. 34, pp. 11-121, 1902.
[9] Smith, A. M., Mica mining in Bengal, India: Mineral Industry, vol. 7, pp. 512-513, 1899.
[10] Mohr, H., Der nutzglimmer, pp. 151-153, Berlin, Gebruder Borntraeger, 1930.

little need to go beyond the original granitic source for most of the muscovite of pegmatites. Although pegmatites yielding commercial sheet mica are only rarely found in the original batholithic source, several of the New Hampshire mica mines are in members of the New Hampshire magma series, which is apparently their source, and scattered references to similar occurrences may be found.

According to Bowen,[11] the pegmatitic liquor is by the very nature of its origin essentially saturated, and its reaction with the wall rock will be chiefly in the nature of the formation of what may be termed addition compounds. Of over two hundred mica pegmatites visited by the writer, there were many in which field evidence showed no such possible amount of assimilation as could possibly produce the tonnage of mica which had been extracted, and the conclusion supporting that of previous investigators is that, while limited assimilation of muscovite or alumina necessary for its formation may take place, the source of the large muscovite books of commercial value is in the magmatic intrustion.

[11] Bowen, N. L., The broader story of magmatic differentiation, briefly told: Ore deposits of the western states, (Lindgren volume), pp. 106-128, Am. Inst. Min. Met. Eng., 1933.

STATUS OF THE CARBON-RATIO THEORY IN ILLINOIS*

By Alfred H. Bell, *State Geological Survey, Urbana, Illinois*

In a paper entitled "Some Relations in Origin between Coal and Petroleum" published in 1915, David White made some generalizations that have been called collectively the "carbon-ratio theory." During the ensuing 20 years many authors have discussed the carbon-ratio theory and some have questioned its validity with respect to specific areas. The purpose of the present paper is to review the pertinent data on coal and petroleum for the State of Illinois and to consider their bearing on the various parts of the carbon-ratio theory.

The fundamental concept of the carbon-ratio theory is that dynamic metamorphism, acting upon rock strata through past geologic ages, has caused progressive increase in the fixed carbon content of coal and in the Baumé gravity of petroleum. From proximate analyses of coal, giving the percentages of four constituents, namely, moisture, volatile combustible matter, fixed carbon and ash, the "carbon-ratio" or per cent fixed carbon in moisture and ash free coal can be calculated. The carbon-ratio of a coal in any locality according to the theory, is an index to the degree of dynamic metamorphism to which the coal and its associated strata have been subjected in that locality. Commercial oil fields, it was found, are confined to areas in which carbon-ratios are not over about 65 (pure coal basis). Some gas fields are located in areas of somewhat higher carbon-ratios but not over 70. No commercial gas or oil are found in areas of carbon-ratio above 70. In some regions a progressive increase in the Baumé gravity of oil (decrease in specific gravity) was noted in going from areas of low carbon-ratio to areas of high carbon-ratio, or from areas of little structural disturbance to those highly disturbed. From these observations it is inferred that dynamic metamorphism acts on oil to change it chemically, making it lighter in gravity until a point is reached at which it is no longer liquid at ordinary temperature and pressure. The boundary between an area in which oil pools occur and an area of higher carbon-ratios in which there are no oil pools is called the "extinction zone." In a recent paper by David White, the extinction zone is placed between carbon-ratios of 61 and 63 (pure coal basis).

If all coals were formed in the same manner from the same original material, and if all determinations of carbon-ratio were made by the same procedure, the variations in carbon-ratio found might be ascribed entirely to varying degrees of subsequent metamorphism. However, it is well known that coals differ greatly in respect to the original material from which they were formed. Methods of sampling coal and of making proximate analyses of coal have differed at different

* Here published in full for the first time; abstract appeared in *Transaction*, Ill. Acad. Sci., 1936. Published with permission of the Chief, State Geological Survey.

times and in different laboratories. A number of different methods have been used to calculate "carbon-ratios." Consequently much caution must be used in any attempt to use carbon-ratios as an index to the degree of dynamic metamorphism.

A discussion by W. T. Thom of sources of error and of limitations to the use of carbon-ratios has been published. After considering the probable maximum variation of carbon-ratios from the "true norm for the metamorphism which such coal samples have suffered," due to initial differences in coal-forming vegetation at time of burial and to errors in sampling, analysis and computation, Thom says "Carbon-ratios appear to provide a fair qualitative index of local metamorphic intensity, but do not give quantitative measures which can be relied on in drawing isocarb contours of less than 5 per cent (average) differences, even when derived with all possible care."

The relative merits of the various methods of computing "carbon-ratio" were also discussed by Thom in the same paper. According to the usage of David White and of most writers on the subject, carbon-ratio is the percentage of fixed carbon in dry ash-free coal computed from the proximate analysis. Thom, on the other hand, advocates the definition of carbon-ratio as the percentage of fixed carbon in moist or "as received" ash-free or mineral-matter-free coal because "the moisture reported in the ordinary proximate analysis must be regarded as an actual constituent of the coal, particularly if the fixed carbon content is to be used broadly as a rough index to the intensity of metamorphic action." An additional but minor point in favor of using the carbon-ratio of the moist coal is that one less experimental determination is involved and hence there is one less chance for error.

Table 1 shows four methods of defining and calculating carbon-ratio. An actual coal analysis is taken for an example and carbon-ratio calculated by each of the four methods. It may be noted

TABLE I.—CALCULATION OF CARBON-RATIO FROM PROXIMATE ANALYSIS OF "AS-RECEIVED" SAMPLE GIVEN THE FOLLOWING ANALYSIS

		"As received" Basis	Moisture Free Basis
Moisture	M_r	15.9 per cent	
Volatile Combustible Matter	VC_r	32.6 per cent	$VC_f = \frac{VC_r}{100-M_r} = 38.8$
Fixed Carbon	FC_r	42.5 per cent	$FC_f = \frac{FC_r}{100-M_r} = 50.5$
Ash	A_r	9.0 per cent	$A_f = \frac{A_r}{100-M_r} = 10.7$
		100.0	
Sulfur	S_r	3.05 per cent	$S_f = \frac{S_r}{100-M_r} = 3.62$

Carbon-Ratio I = Per cent fixed carbon in "pure coal" or dry ash free coal

$$\frac{FC_r \times 100}{100 - (M_r + A_r)} = \frac{42.5 \times 100}{100 - (15.9 + 9.0)} = 56.6$$

Carbon-Ratio II = Per cent fixed carbon in "unit coal" or dry mineral matter free coal

$$\frac{100\ (FC_f - .15\ S_f)}{100 - (1.08\ A_f + .55\ S_f)} = \frac{100\ (50.5 - .15 \times 3.62)}{100 - (1.08 \times 10.7 + .55 \times 3.62)} = 57.8$$

Carbon-ratio III = Per cent fixed carbon in "as-received, ash-free, or moist, ash free" coal

$$\frac{FC_r \times 100}{100 - A_r} = \frac{42.5 \times 100}{100 - 9.0} = 46.7$$

Carbon-Ratio IV = Per cent fixed carbon in "as-received, mineral matter free, or moist mineral matter free" coal

$$\frac{100\ (FC_r - .15\ S_r)}{100 - (1.08\ A_r + .55\ S_r)} = \frac{100\ (42.5 - .15 \times 3.05)}{100 - (1.08 \times 9.0 + .55 \times 3.05)} = 47.5$$

that carbon-ratios on the dry coal basis are considerably higher numerically than those on the moist coal basis but the numerical differences resulting from the use of mineral-matter-free instead of ash-free coal are comparatively small and of the order of 1 per cent. Hence in making use of carbon-ratios from different sources, those for moist coal must not be compared directly with those on dry coal although it is permissible when studying large regions to use mineral-matter-free and ash-free carbon-ratios on the same map.

In the present study of Illinois carbon-ratios isocarb maps were made for both dry and moist carbon-ratios. Although both maps showed the same broad features, the map of moist carbon-ratios was more consistent and the variations in carbon-ratio were less abrupt in some areas than in the map of dry carbon-ratios.

Figure 1 includes two maps, one showing structure and the other showing carbon-ratios. The structural key horizon in all but eastern Illinois is the top of coal No. 6, and the contour interval 100 feet. In the area of the LaSalle anticline in eastern Illinois, the key horizon is the base of the Sweetland Creek and top of the Devonian limestone. The principal structural features shown are the large basin which includes all of the Pennsylvanian area in Illinois and extends beyond the state border into Indiana and Kentucky, the LaSalle anticline and the Duquoin "anticline" or, more appropriately, monocline. Areas of abundant faults in the southern part of the State are outlined by dotted lines.

The carbon-ratios shown are the percentages of fixed carbon in moist mineral-matter-free coal (No. IV, Table 1). Datum points are not shown. Each datum point represents one mine and in most cases is an average of the analyses of several face samples. The great majority of the analyses were of coal No. 6. Those in the northern part of the area were of coal No. 5, No. 2 and No. 1. According to Hilt's law, carbon-ratios increase with depth of burial and with geologic age for different coals at the same location. Therefore, if carbon-ratios of different coals are to be used in drawing isocarbs, they should all be referred to a single horizon by adding or subtracting an amount which is the average difference in carbon-ratio of the given coal and the coal at the reference horizon over an area in which both coals occur. This is difficult, however, because in most districts only one coal is mined, and data are insufficient to obtain a reliable value for the average difference in carbon-ratio between any two coals in the same area. Moreover, there are some instances where an upper coal has a higher carbon-ratio than a lower coal at the same locality. In such cases it is evident that other factors such as original constitution of the coal-forming material had more influence in determining carbon-ratio than did depth of burial. Available data show that average differences in carbon-ratio of the various coals used in this study are considerably less than the isocarb contour interval of 5 per cent. Accordingly it was decided not to use a correction to a single reference horizon.

The isocarb map shows progressive increase in carbon-ratio in going from north to south toward the faulted area in southern Illinois. Data are lacking in the central part of the basin and in most of the LaSalle anticline area but the isocarbs have been tentatively drawn to show a high in this area, and a low in the basin area to the west. A pronounced carbon-ratio high extends northward from the southern part of Williamson County a few miles east of the Duquoin anticline. This coincides in location with a belt of faulting which extends northward into Franklin County. Some of the smaller carbon-ratio highs, however, are not connected with known structural features. Attention is here called to the fact that a majority of the oil and gas pools of the State are located on or near carbon-ratio highs. Those that are not so located as shown by the present map are nearly all in areas where carbon-ratio data are scarce or lacking, as for example the Jacksonville gas field, the Colman-Plymouth oil field, the Waterloo and Dupo oil fields. There is a suggestion that the carbon-ratio highs were caused by forces of structural deformation which at the same time favored the accumulation of oil and gas.

Figure 2 is a carbon-ratio and structure map of the southern part of Illinois. It is on a larger scale and is more detailed than Fig. 1. Instead of the boundaries of faulted areas, the location of the faults themselves is shown. In addition to the

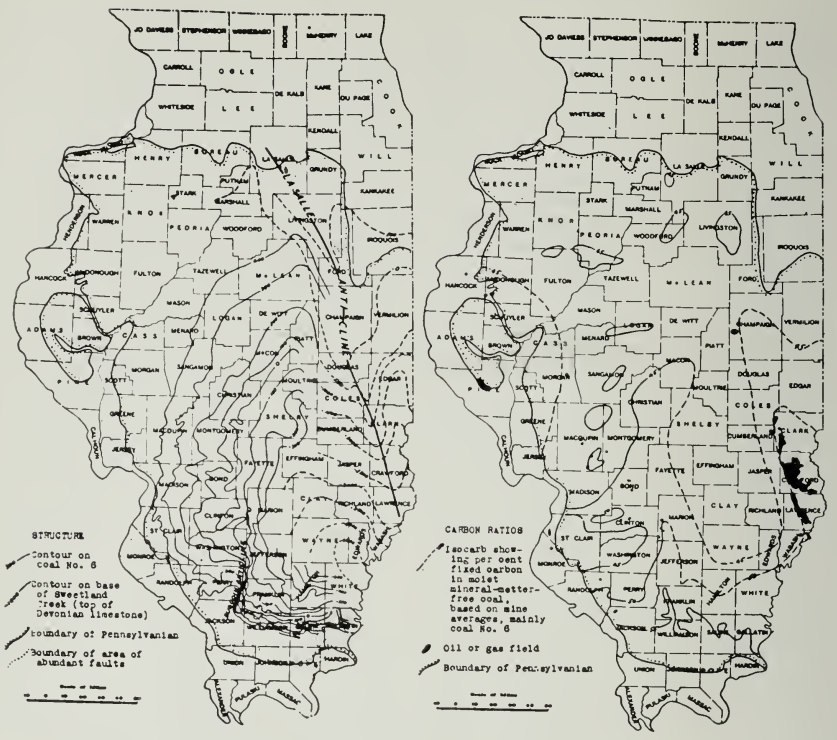


FIG. 1.

oil and gas fields which are named, the location of important oil shows are indicated. One of these, which was a 2-barrel show in the Ste. Genevieve limestone (Lower Mississippian) is located on a carbon-ratio high.

Variations in oil gravity in Illinois are greater in different stratigraphic horizons in one locality than they are for oil from one stratigraphic horizon in different locations. There is no recognizable relationship between areal variations in oil gravity in Illinois and areal variations in either carbon-ratios or degree of structural disturbance. This lack of correlation may be due largely to the fact that the known oil and gas fields of the State are confined to areas in which the range of carbon-ratio variation and in degree of structural disturbance is considerably less than the total range for the whole State.

The data presented above on carbon-ratios and structure in Illinois definitely indicate a relationship between regional variations in carbon-ratio and degree of structural disturbance. However, the greatest degree of structural disturbance in the coal basin of Illinois, which occurs in the Illinois Ozarks, falls far short of that in the intensely folded anthracite region of Pennsylvania, and therefore conditions in Illinois are not suited for a complete investigation of the carbon-ratio theory.

Carbon-ratio data may be of some assistance in future prospecting for new oil and gas fields in Illinois by suggesting territory in which probabilities appear greater than in neighboring territory. They cannot be expected to provide as good a basis for recommending definite locations for drilling as detailed structural data. Nor can any part of Illinois be eliminated from consideration as prospective oil territory on the basis of carbon-ratio data.

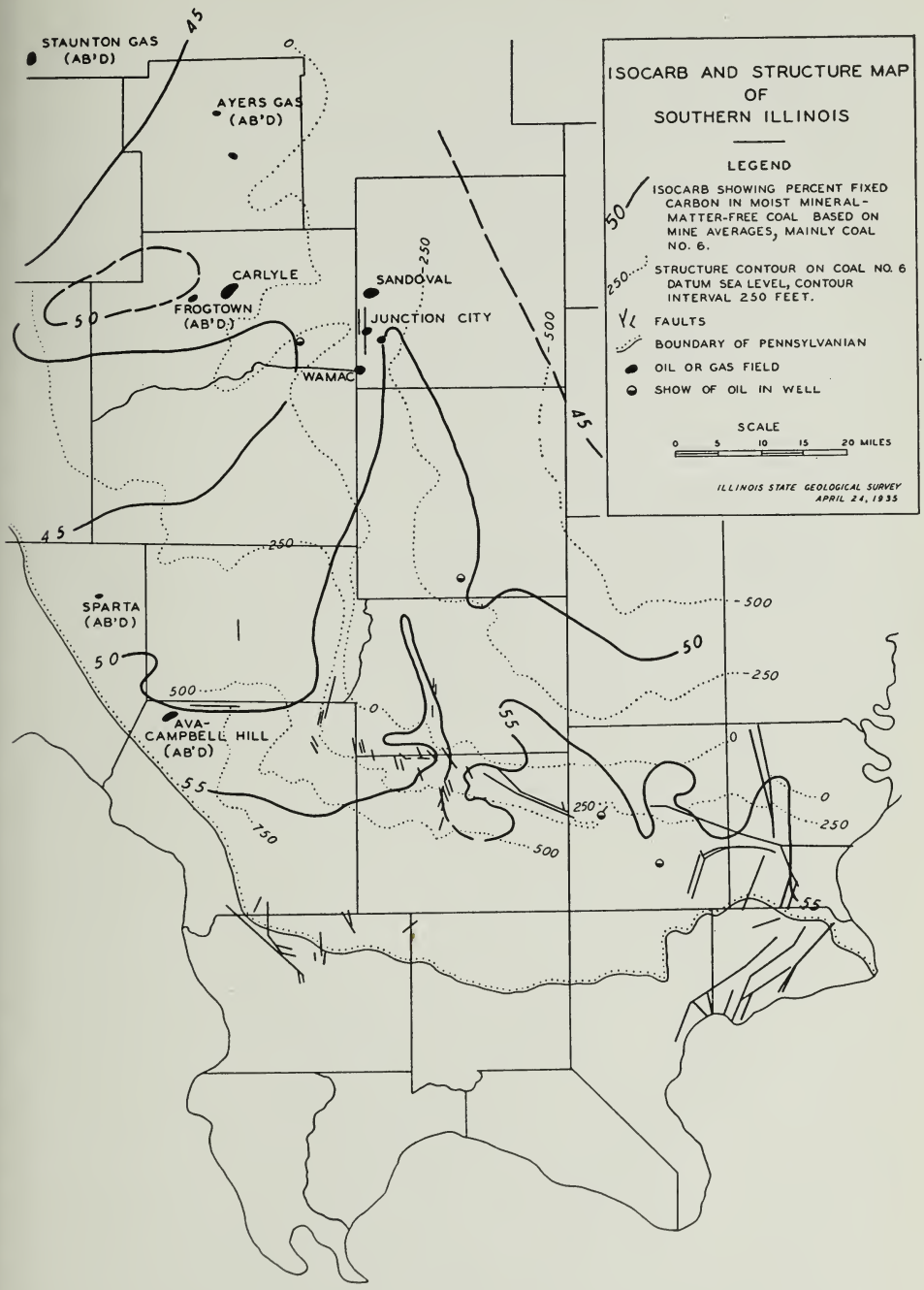


FIG. 2. To accompany "*Status of Carbon-Ratio Theory in Illinois,*" by A. H. Bell.

Papers in Physics

Extract From the Report of the Section Chairman

The Evanston program carried 20 papers, 12 of which are herewith published. The others were:

Eaton, D. H., *Northern Illinois State Teachers College, DeKalb.*—Internal resistance of polarized cells.

Hinch, W. H., *Central Scientific Co., Chicago.*—The lift and drag forces in a model airplane wing.

Krans, D. H., *University of Illinois, Urbana.*—Experimental investigation of the flow-energy equation.

Long, V. A., *Bradley Polytechnic Institute, Peoria.*—Fluctuational effects in cosmic-ray ionization.

Peck, E. R., *University of Chicago, Chicago.*—High dispersion photometry of ultra violet absorption spectra using Geiger counters.

Smith, Roland, Jr., *Northwestern University, Evanston.*—The electromagnetically driven tuning fork.

Spence, B. G., *Northwestern University, Evanston.*—General plan and equipment of the new Northwestern University physics laboratory.

Steinhaus, David, *Lake Forest College, Lake Forest.*—Some experiments with a flicker photometer.

Frank L. Verwiebe, Eastern Illinois State Teachers College, Charleston, was elected chairman for the Urbana meeting.

(Signed) Ph. A. Constantinides, *Chairman*

PROGRESS IN THEORY AND USE OF CONCAVE GRATINGS

H. Beutler

University of Chicago, Chicago, Illinois

In 1882, Rowland invented the concave grating and thus created a simple and very powerful instrument for obtaining spectra of high resolution and dispersion. Since then, some changes in the mounting of the grating have been introduced, and grazing incidence has been used for exploring short wave-lengths in vacuum spectroscopy.

The investigation of the spectra of polyatomic molecules necessitates the application of the highest possible resolving power over extended regions of the spectrum, excluding thereby interferometers and requiring the extension of the limits in resolution that can be obtained by gratings. A more general treatment of the theory of image formation by the concave grating was therefore started, extending the calculations into three dimensions.

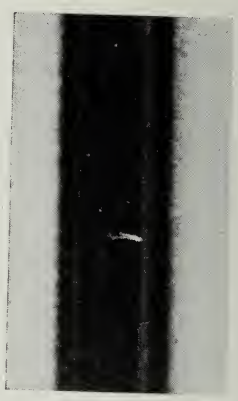
A grating is defined by its radius of curvature, R, and by the spacing of the grooves, d; in addition, by the area on which grooves of length, l, are ruled over a width, w. We can describe then every point P on the grating's surface by Cartesian coordinates l, w and ξ, with origin at the center 0 of the grating. In front of the grating lies a point light source A, with the cylindrical coordinates (origin at 0) r, α and z, and an image point B with r', β and z'. The coordinates l, z and z' are then parallel.

For the paths of the light diffracted on the grooves the following function holds:

$$F = AP + BP + m.\lambda.\frac{w}{d},$$

where λ is the wavelength and m the spectral order of the light appearing at B. The function F is a complicated power series in R, l, R^{-1}, R^{-2} ....., containing as factors α,β, w and l in ascending powers. To have the light from A focused at B, the function F has to fulfill Fermat's conditions:

$$\frac{\partial F}{\partial w} = 0 \; ; \quad \frac{\partial F}{\partial l} = 0.$$



Mercury line 2537Å, showing the five hyperfinestructure components. The separation of the middle components requires a resolving power of 300,000.

The first condition yields in first approximation the formula for the plane grating, λ as function of α and β, that holds also for the Rowland circle. Further, it defines in higher approximation the Rowland circle as the locus for slit and image. The second condition does not hold for the Rowland circle, but gives rise to astigmatism by drawing each point light source out to a line. But this elongation occurs strictly in the direction of the slit and does not impair the definition of the spectral lines, only their intensity. This astigmatism for all angles α and β is graphically represented in three diagrams, one showing the length z' to which the image of a point is elongated; the second gives the length of the luminous slit necessary to obtain a spectral line that has the maximum intensity over 5 mm along its center; the third graph shows the position in front of the slit that a light source should have in order to be focused on the Rowland circle.

The focusing conditions for Wadsworth's mounting are to be found by setting $r = \infty$ (parallel light). The astigmatism for points outside of the normal has been calculated.

But the partial differential $\frac{\partial F}{\partial w}$ cannot be kept exactly equal to zero. The maximum value allowed is $\frac{\lambda}{4}$, lest extinction of the image occur by spherical aberration. The latter limits the allowed length l and width w of the grating simultaneously, and thus limits the maximum resolving power. A graph represents the allowed areas for all angles α and β.

There are some cross terms contained in the series development of F, involving $w.l^2.f\ (\alpha, \beta, R)$. They indicate the presence of coma in the image formation. The magnitude is represented in a graph. In practice it is necessary to limit its amount by restricting the length of the groovés.

The same cross term causes the curvature of the spectral lines, the calculation of which has been carried through. This information is often necessary to insure the highest accuracy in the measurement of the plates, or to utilize the grating as a monochromator with a straight or curved exit slit.

These derivations of the imperfections in the image formation enable one to distinguish between the defects in the adjustment and the errors in the grating itself. They allow a safe quantitative judgment about the maximum resolving power obtainable by a given grating.

In addition they allow one to compensate for errors in the grating by slight changes in the mounting. Thus, the sperical aberration can be utilized to compensate for the error run of the ruling of the grating, by setting not the geometrical center but another point of the grating (along its "equator") tangent to the Rowland circle. Thereby, the exact circle is retained as focal curve. By this means, three big gratings have been adjusted on the same Rowland circle of 30 feet diameter. Each of these gratings yields a resolving power up to 300,000 and 400,000. The advantage of having multiple gratings is that a high intensity can be procured over a wide wavelength range, since each grating has a maximum reflectivity over a small angular range only.

Some reproductions of spectral lines of mercury are shown in the figure, which indicate in the resolved hyperfine structure a resolution of more than 300,000 obtained with our gratings.

I take pleasure in acknowledging the cooperation of Dr. Mark Fred, N. Metropolis, and A. T. Wager in the work leading to these results.

TWO SIMPLE PIECES OF APPARATUS FOR LECTURE DEMONSTRATION IN GENERAL PHYSICS

M. Alden Countryman
Illinois Institute of Technology, Chicago, Illinois

Two simple pieces of lecture demonstration apparatus are presented: one an electromagnet made from the field structure from an old 'Edison' type D. C. generator with suitable accessory parts to conveniently demonstrate the Faraday disc or Homopolar Generator, Barlow's wheel, the action of a D'Arsonval galvanometer, electromagnetic damping, and the moving element oscillograph, and the other a modification of the usual device for demonstrating the addition of colored lights. This latter device consists of three small lamp houses each equipped with one of the three color-separation filters supplied by the Eastman Kodak Company, and so mounted as to swing in a vertical arc about a central white circular plane having at its center an equilateral triangular pyramid also white. When the lights and pyramid are adjusted so that each light shines on a separate face of the pyramid each primary color is separately visible. As the pyramid is rotated, any pair of colored lights are additively combined in variable proportions on a single face of the pyramid, and when the three lights are swung down they all three combine on a single face of the pyramid and thus demonstrate rather strikingly that if the three colors are the three primary colors, their additive combination must necessarily—and does actually—produce the sensation of white.

THE METERING OF PROJECTION PRINTING

ROSCOE E. HARRIS
Lake Forest College, Lake Forest, Illinois

A simple photometer for accurately metering the intensity of various parts of the negative image is a very useful dark room adjunct in making projection prints from miniature negatives. The one shown in the orthographic projection has proved to be accurate to .01 candle meter.

This drawing (fig. 1) shows the elevations with front and side removed and the top view with the top partially cut away. There is a small room containing a 5-watt lamp and switch, light shielded from the rest of the case except for a small window in the side wall (shown shaded in the drawing). This window is covered with white paper as a diffusing matt, and is shuttered by a variable disc (A) turned by a knob graduated in candle meters on the right hand side of the case. The light may be varied from zero to the upper limit, which may be varied by changing the size of the window or by changing the baffling on the sides of the case (not shown in the figure). These baffles are simply pieces of black, white, and blue paper on the inner walls to change the amount and color value of the light that illuminates the plate B that covers half of the field of view. Ususally 1 candle meter is sufficient range for amateur photographic enlargement. The intensity of B may thus be varied from zero to 1 candle meter without changing the color of the light. A rheostat control is not practicable because of color change and lack of constancy of the rheostat with temperature changes. The sight tube directs the vision thru an aperture stop C, which is adjustable as indicated, onto a field of view one-half of which is covered by the plate B, and the other half covers a portion of the negative image being metered. This limitation of the field of view is essential in visual comparisons of brightness. A blue filter placed over this aperture makes its possible to work with a bright red light on all the time, and completely corrects any color differences.

In use, it is necessary to have a fair notion of the sensitometry of the paper.

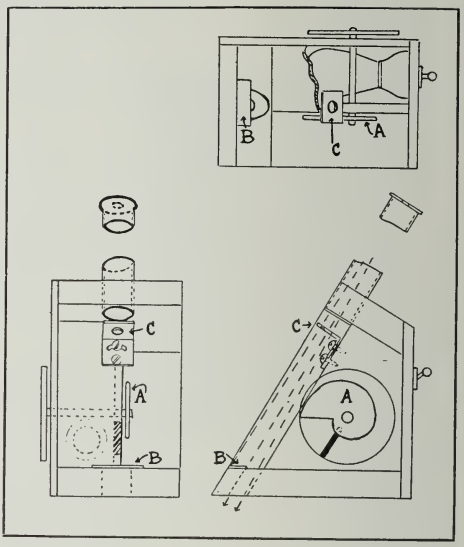


Fig. 1.

For example, a contrast grade of bromide paper has a lower threshold at about 0.5 candle meter second (c.m.s.), a middle grey exposure of 1½ to 2 c.m.s., and an upper threshold of 7 c.m.s. Suppose that the negative is projected and a portion selected in the middle grey, that in the artist's judgment requires 1.5 c.m.s. exposure. The photometer may be set at .10 candle meter and the projector diaphragm adjusted until this portion matches in the photometer field. Then 15 seconds exposure should be correct for the entire negative.

Differently exposed negatives will require other photometer settings. It is interesting to meter other spots in the shadows and highlights and calculate the exposure these portions will receive. Thus a grade of paper may be selected that would bring out the full merits of the negative.

The photometer has been used for measuring brightness of dimly lighted rooms, absorption of wall papers, etc.

Sufficient detail is included in the figure so that any one may construct the apparatus for his own dark room.

DIFFERENCES OF ELECTRIC POTENTIAL IN THE LEAVES OF PLANTS

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Differences of electric potential appear to exist in all living organisms. Physiologists and biophysicists are studying these differences of potential in an attempt to discover their origin, and to determine whether they are, as some investigators think, mere indicators of processes going on in the organism or whether they exert some control over these processes. Knowledge of the factors which influence these differences of potential, not only assists in arriving at a solution of the problem of their origin[1, 2, 3] but also makes it possible in some cases to use them to indicate changes going on within an organism without probing within that organism or injuring it in any way. Since these differences in electric potential in plants and animals are affected by numerous physical conditions, many of which undoubtedly are yet unknown, experiments are difficult to control and it is well to have similar experiments repeated by several investigators. One of the factors most studied has been the influence of light on the potential differences between two points on the leaves of plants.[4, 5] I am presenting data which I have obtained on changes in potential difference produced between a point near the basal end of a leaf and another point near the apical end when an area between these points is irradiated by visible light.

Poinsettia leaves growing on the plant have been used throughout these experiments. The differences of potential are measured by a Compton quadrant electrometer. The electrometer is housed in an earthed electrostatic shield near which is placed another earthed metallic box containing the plant whose leaf is to be used in the experiment. The pot in which the plant is growing is insulated on a paraffined wooden block. The leaf is encased in a transparent plastic box in such a manner that the leaf is supported in a horizontal position on the bottom of the box. L-shaped electrodes of silver wire pass through slots in the sides of the box. One end of each electrode

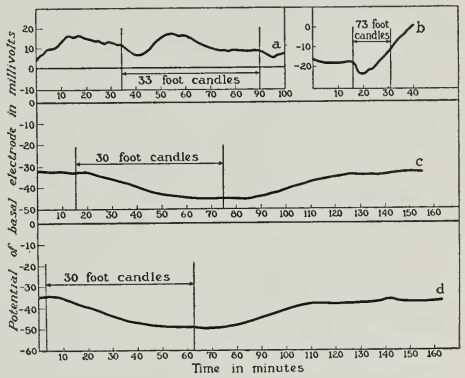

Fig. 1.

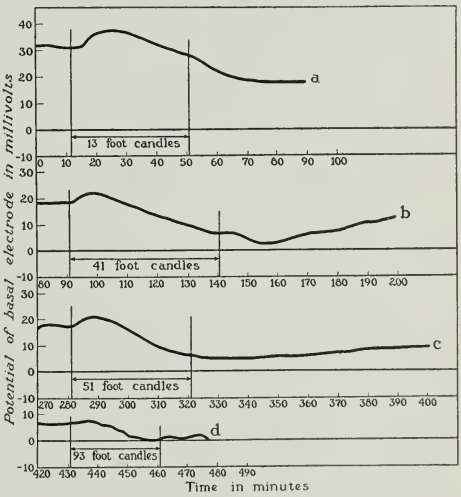

Fig. 2.

has been chloridinized and dips into a drop of tap water placed upon the leaf. The electrode near the basal end is connected by means of a switch to the insulated quadrants of the electrometer. The metal box which contains the plant is painted black inside. An adjustable opening on top admits light from an incandescent lamp directly above it. A water filter is used to absorb much of the infra-red radiation from the lamp. A

piece of heavy black paper with a rectangular opening placed on top of the plastic box is used to admit the light to the desired area between the electrodes. The intensity of the light which falls on the leaf is determined by removing the leaf and putting in its place a thermopile.

The type of response obtained is shown in figs. 1 and 2. The curve gives in each case the variation with time of the potential of the basal electrode with respect to the apical electrode which in turn is earthed. The arrows indicate the intensity of the light used and the duration of the exposure. Curve *a* of fig. 1 represents the condition in which the plant had been kept in a dimly lighted room for several hours before the application of the electrodes. Readings of the potential were started as soon as the electrodes were applied. The initial variations can be ascribed to the disturbance caused by mechanical manipulation in setting the plant up for the experiment. In this case an appreciable change in potential was produced by the illumination. Curve *b* (fig. 1) shows the response of the same leaf on the following morning. The plant had been left over night entirely undisturbed in the light tight box. In both of these sets of determinations the light was allowed to fall over the whole of the plant.

Curves *c* and *d* show the response of a leaf irradiated on two different occasions with light of the same intensity, for the same length of time, and over the same area between the electrodes. An interval of an hour's time during which the plant was left undisturbed in the dark, elapsed between the two series of observations. The two responses were nearly indentical. Fig. 2 shows the effect on the potential difference of successive irradiations of the same area of a leaf by light of increasing intensity. It will be noted that the magnitude of the response in general decreases with the increase in intensity of light, but the response takes place more rapidly. The plants represented by curves *c* and *d* of fig. 1 and by those of fig. 2 were kept over night in the light tight box before observations were started.

The variation in potential difference observed in *Poinsettia* leaves with irradiation by visible light is similar to that obtained by other observers for the same[6] and for different leaves[7] using somewhat different procedures. The results under the conditions represented by fig. 2 are not inconsistent with those of Marsh[8] working with *Valonia*, but many more observations must be made before a definite conclusion can be reached.

It should be remarked that the mangnitude of the response to irradiation varies greatly. Many times it is so small as to make the change indecisive. Keeping the plant in the dark for several hours will often increase the response, but sometimes two days in the dark will not be sufficient to make the response appreciable. Small responses seem to be found more often in summer than in winter. Whether the season, the condition of the plant, its environment, or the conditions under which it was grown are responsible for this lack of change is still to be determined.

I should like to express my appreciation of the interest and assistance given to this work by Dr. Charles Sheard of the Mayo Foundation, and to the Illinois State Academy of Science for a grant of money which has made it possible to continue the work at Rockford College.

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RADIOACTIVE TIPS FOR THE LECTURE TABLE

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A number of years ago the author[1] described a radioactive tip consisting of a solid cane of Pyrex glass about 2 mm in diameter and 5 cm long carrying on one end a minute quantity of a radioactive salt of high activity for furnishing the source of positive rays (alpha particles) in a simple Wilson cloud chamber.

To prevent the radioactive material from flooding the chamber with emanation, and also to guard against the active salt being washed off by coming in contact with the water within the apparatus when in use, the tip carrying the salt was (and still is) covered with a very thin film of glass (Pyrex) to keep back the emanation but which allows the alpha particles to pass freely.

The tip while being fabricated is tested by placing it temporarily in a cloud chamber. If less than 5 alpha ray tracks result on each expansion it is rejected. An occasional one may give 10 to 15 tracks. For purposes however of showing the phenomenon to a class the number of resulting tracks should be between 5 and 10. More than 10 is like watching a four ring circus.

These tips are being used at the present time for other purposes in the physical sciences, notably for showing the discharge of electroscopes on the lecture table. For this purpose stronger tips are desired. The stronger the tip, i.e., the more radioactive material that it carries, the more rapid the discharging effect, and also the farther away this effect may be noticed.

Tips that are used in the open should be handled with care. The active end with its covering of thin mocroscopic glass is easily injured by touching with the finger or by rough handling. Tips for lecture table demonstrations should each produce from 25 to 50 alpha ray tracks on expansion. It is impracticable to make each larger or stronger because of constructional difficulties. Hence if sources of radioactivity of greater strength than 50 alpha ray tracks (on the scale cited above) are desired, as in the case of discharging an electroscope at a distance, two or more tips may be assembled in bundles as shown in fig.1.

In the figure, *a* represents a single finished unmounted tip. It is in this form that they have their greatest use.

To prevent the active ends from being touched in handling, or injury in use, it is recommended that these bundles be mounted in glass envelopes the open end of each to project about 2 mm beyond the ends of the tips encased. The mounting of a single cane is shown at b in fig. 1; and for a bundle of 3 canes, at c. The corresponding end views are also shown. The mount is entirely of glass

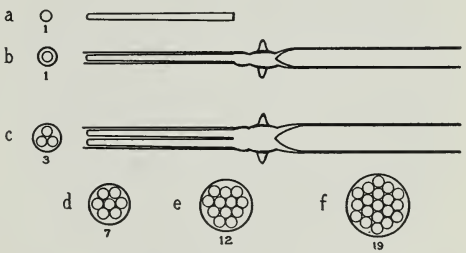

Fig. 1

and with handle is about 15 cm long. To prevent it from rolling off the table each envelope has 3 equally spaced glass nibs fused on it (only two are shown) as indicated at *b* and *c*. The end views of these larger bundles containing 7, 12, and 19 tips respectively, mounted within glass envelopes, are shown at *d*, *e*, and *f*.

Obviously, for a given distance from an electroscope, the rate of discharging it is directly proportional to the number of tips, providing of course that all emit approximately the same number of alpha particles. This condition is approached as nearly as possible in their manufacture. A strong radioactive deposit will fail to produce tracks (when tested as above indicated) if a thick film of glass is used for a cover. Hence great care must be exercised in their fabrication, and, further, radioactive salt of suitable intensity is expensive.

FORMS OF DISCHARGE IN MICRO-GAPS

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The potential required to produce a disruptive discharge between two electrodes immersed in a gas has been studied by a large number of workers. At gas pressures of 150 cm and less the breakdown potential follows Paschen's Law, that is $V_s = f(p \times d)$. The curve of breakdown potential versus electrode separation in this pressure range is characterized by a pronounced minimum potential, below which it is impossible to obtain a spark breakdown.

Hobbs[1] and others have shown that at atmospheric pressure there is a significant departure from Paschen's Law, in that the breakdown characteristic does not exhibit a minimum value. Instead, the potential at very small gaps decreases linearly to zero, which suggests a field dependent discharge. All the fields reported in the literature are of the order of 10^6 volts per cm. Although this is the order of field strength within which field currents have been obtained in vacuum, it was not until a recent paper by Pearson[2] that any measurements of field currents at atmospheric pressure were reported.

The discharge or breakdown at gaps of the order of 10^{-4} cm takes several different forms. At gaps somewhat smaller than this value, it has been generally observed that the breakdown results in cohesion or short circuit of the contacts. This cohesion has been shown to consist of a bridge of electrode metal. At gaps somewhat greater than 10^{-4} cm, it is found that breakdown results in a more or less stable discharge of the nature of an arc. It should be pointed out that the breakdown described above may occur at potentials less than the minimum sparking potential as given by the Paschen curve. Eskin[3] previously suggested that this type of breakdown might well explain the reignition of AC arcs.

The authors, working with polished silver electrodes, have observed that the breakdown potential for these micro-gaps is dependent upon their history. This is perhaps best seen by reference to table I, which shows the manner in which the breakdown voltage changes with the magnitude of the initial applied potential. In the case of electrodes 1 to 4 the initially applied potential of 10 volts was increased in steps of 10 volts, each step being held for 5 seconds, until breakdown occurred at the voltage indicated. For electrodes 5 to 12, in all except one case, breakdown was observed at the initial potential.

Table I.—Effect of Initial Voltage on Breakdown

Electrode number	Initial voltage	Breakdown voltage	Gap (Cm)
1.....	10	320	.000052
2.....	10	320	"
3.....	10	290	"
4.....	10	260	"
5.....	120	120	"
6.....	120	...	"
7.....	120	120	"
8.....	120	120	"
9.....	130	130	"
10.....	130	130	"
11.....	130	130	"
12.....	130	130	"

Previous observations of the breakdown of these micro-gaps were made with the use of a voltmeter connected across the electrodes. Series resistance was used with the contacts, and the decrease in potential across the electrodes was taken as indication of a discharge. In the present study it has been found that transient discharges occur between polished silver electrodes before a breakdown (either cohesion or a stable discharge) takes place. These discharges are faintly audible, and luminous when observed in a darkened room, although it was found impossible to detect them on a voltmeter connected across the contacts. These discharges were characterized, however, by a variety of markings left upon the electrode surfaces. These markings are entirely different from those observed following a complete breakdown.

The markings observed were of two

[1] G. M. Hobbs, Phil. Mag. (6) 10, 617, 1905.
[2] G. L. Pearson, Phys. Rev. 56, 471, 1939.
[3] S. G. Eskin, J. App. Phys. 10, 631, 1939.

distinct varieties. In fig. 1 is shown a so-called "bird shot" pattern. The markings were somewhat less than 1 mm in diameter, and the cathode marking was always found to be more extensive than the one on the anode. In general, this type of marking occurred with a low series resistance (76 ohms) and at a voltage of less than about 250 volts.

Fig. 2 shows a ring pattern, which consists of a number of concentric colored rings. This type of marking was observed in general with relatively high series resistance (1000 ohms) and at potentials above 270 volts. In some instances the rings completely filled the area, leaving no clear central region as shown in fig. 2. In other cases, a bird shot pattern has been observed within the central area of a ring pattern.

Using an extremely high series resistance (10^{10} ohms) and a galvanometer in series with the electrodes, current pulses were observed within this range of gaps and voltages. At a given gap setting, these current pulses appear quite at random for voltages below 320 volts, but above this value, however, the pulses appear at more or less regular intervals until at 350 volts or so, the pulses are quite regularly spaced, having frequencies of the order of 30 per minute. A further increase in voltage greatly increases the frequency, until finally cohesion results. Each pulse is accompanied by a luminous discharge in the gap, but no markings such as described above have been observed on the elctrodes.

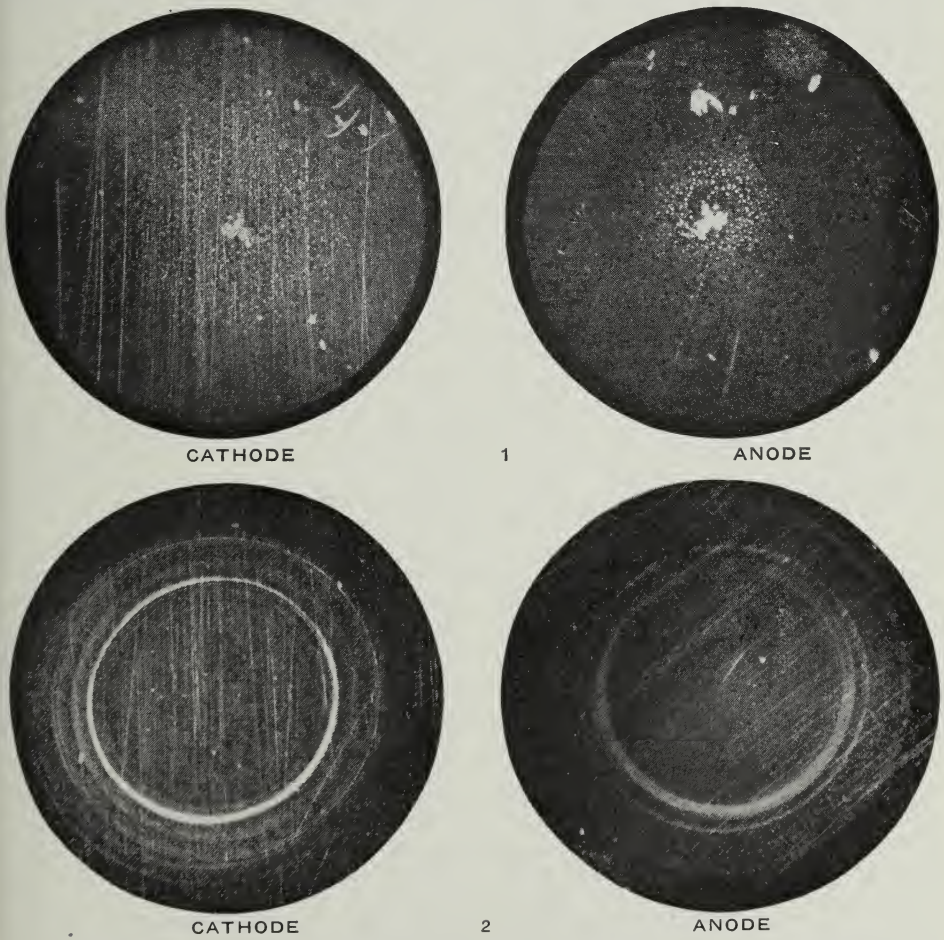

Plate I.—Electrode surface markings following a transient discharge. 1. Shows "bird-shot" 2. Shows ring pattern.

OBSERVING AND MEASURING SWAY IN A TALL BUILDING

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A very comprehensive study of wind forces extending over a five year period of observation on the Empire State Building is reported in the Proceedings of the American Society of Civil Engineers, September, 1938. It seemed of interest to compare the results of a similar study on a fifteen story building with those on one hundred and two stories. Although our study was begun only two months ago the data collected lead to several interesting and confirming results.

The building in which the observations reported were made is Mundelein College for Women, located on Sheridan Road at Devon Avenue in Chicago. The total height above the street level is 208 feet. Above the fourth floor there is symmetry along one axis extending north and south. Structurally this building consists of reinforced concrete construction, the outer walls of which are covered with limestone. The partitions are of tile and plaster and the floors of concrete, pan construction. Much of this material is not elastic and does not follow Hooke's law. As a result when it is subjected to loads, the building shows a slight amount of plastic action; that is, when it is deflected by a horizontal force it will not return exactly to a definite fixed position.

The story height, the length of the resisting walls, the number of windows, the type of masonry, the sequence in which the different stories were built and the temperature—all affect the damping resistance, and these variables make it impossible to predict what the ratios of resistance will be in any given building. After many high winds the wall resistance probably diminishes.

For these reasons engineers design for elastic resistance only. Even there the variables are so many, and so many approximate assumptions are necessary that their best design figures are plus or minus ten per-cent. Their aim is to so frame the building that under the maximum "twenty-year-wind" in the most effective direction the yield point of the elastic materials will not be exceeded.

The buildings in the vicinity of the structure are of varying heights ranging from low two story residences to seventeen story apartment buildings. A study of the character of the obstructions which, it was easily seen, were of the type that would disturb the air currents, was undertaken for a radius of four blocks. North and northwest, south and southwest are the directions of greatest obstruction. The entire east side is exposed to the Lake and the west side has but one building as tall as seven stories.

Two methods of taking observations were used. In one the dial on the four-cup anemometer and the direction of the wind were read just before and just after the deflection readings. The average velocity was taken and not the maximum. In the other half hour deflection readings were automatically recorded on a single recording sheet for a period of eight hours each day. These cluster points were interpreted on the basis of average deflection and average anemometer readings which were taken hourly during the corresponding day.

A pendulum hanging from a point between the eighth and ninth floors with a 110 lb. bob poised over a recording table was adjusted to a chosen zero point at the centre of a graduated circle directed toward the compass points. A sheet of polar coordinate paper was placed between the tungsten point on the lower surface of the bob and a copper plate on the recording table. For one type of observation the automatic timing device closed the circuit every half hour, and a perforation was made in the polar coordinate paper. For the other, a new sheet of polar co-ordinate paper was slipped into the gap and properly orientated, the switch manipulated manually, and the reading taken.

By either method the deflection for wind velocity up to 20 miles per hour did not exceed 0.15 inches with the lower limit at 0.08 inches. At no time did the deflection reading return to the chosen zero point. The data reported herein are those of the movement of the ninth floor relative to a point 120 feet below, the

lateral movement of which is doubtless small and may be neglected.

In effect, the building has two distinct movements. It deflects from the vertical and it vibrates with a definite period, similar to the prongs of a tuning fork when struck. A steady wind causes deflections only, whereas a gusty wind will set up vibrations with amplitudes that vary with the strength and character of the storm.

To study the vibration of the building a transit instrument was set up in the pendulum shaft and sighted on a target on the top of the shaft. Up to the present the amplitude of vibration has been too small to be detected. As the pendulum did not record movements of its support that are not of greater duration than the period of its swing, which is 11.92 seconds, the building vibrations are not recorded by the bob, but their mean position is determined by it.

Observation of the air currents around the structure were made on April 25, at 3 o'clock in the afternoon during a seven mile per hour wind blowing from the east. A rubber balloon was tied to a long thread and sent out from several predetermined points near corners on the 4th, 8th, and 14th stories. These data show that the flow of air is greatly disturbed by the building in a manner far from simple.

The following conclusions directly confirm those of the study made on the Empire State Building:

(1) The distribution of the wind pressure on a tall building is very complicated and irregular; the air currents having broken up by the surrounding structures and by the building itself.

(2) The action of the building under horizontal loads is plastic as well as elastic, with the result that strains and deflections are not proportional to the forces that produce them.

THE USE OF THE PERIODOGRAM IN ESTABLISHING THE REALITY OF HIDDEN OR SUSPECTED PERIODICITIES

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The investigation for the evidence as to the realtity of a periodic change in the intensity of cosmic rays with respect to sidereal time is rendered unusually difficult for three reasons:

1. The sidereal diurnal period is only four minutes shorter than the solar diurnal period, or about 1/365 of a solar day.
2. In addition to this very minute difference in the periods, the sidereal variation is much smaller than the solar variation.
3. The amount of data available is limited and does not extend in most projects beyond three or four years.

The appearance of a sidereal variation upon mathematical analysis by no means establishes the reality of the sidereal variation, for with a seasonal change there is introduced by formal analysis a variation which is spurious at a frequency corresponding to the sidereal day. The appearance of such a spurious frequency further complicates the problem.

If a function f(t) be periodic with two periods T_1 and T_2, and if

$$a = \frac{2}{Tn} \int_0^{NT} f(t) \cos kt \, dt$$

$$b = \frac{2}{Tn} \int_0^{NT} f(t) \sin kt \, dt$$

$$c^2 = a^2 + b^2$$

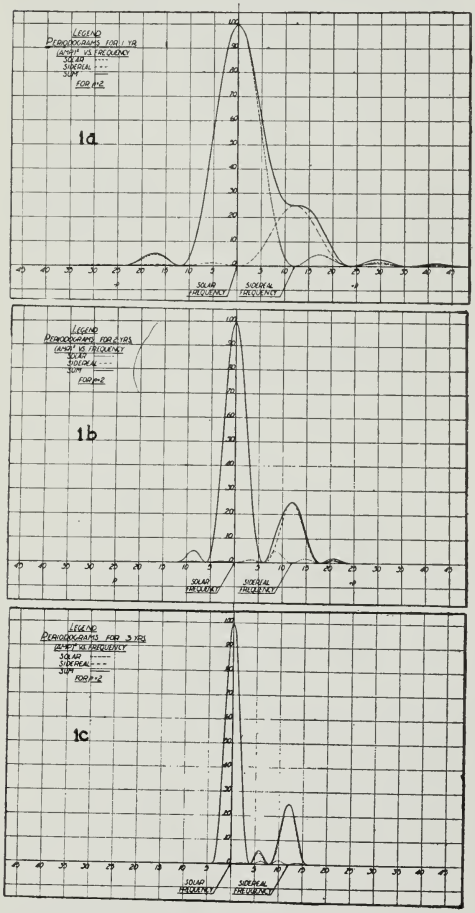
then c^2 which depends upon T, the period, n, the number of observations, and the amplitudes of the variations will have values other than zero at points corresponding to the two periods. The values between the points corresponding to the periods T_1 and T_2 may not be zero if the amplitudes are large and the observations few in number. The curve obtained by plotting c^2 against T is called the *periodogram.* Beyond the abscissae T_1 and T_2 the value of c^2 falls off to zero very rapidly.

The ordinates of the two peaks (at T_1 and T_2) will depend upon the amplitudes of the two variations. Here again, be-

of the finite limits of the Fourier Integrals spurious periodicities are introduced giving secondary maxima on either side of the principal maximum, but these spurious maxima may be distinguished from the real (fig.1a), since with increasing data these secondary peaks move toward their respective principal maxima (fig.1b and 1c).

The calculation of amplitudes corresponding to different periods may be performed by Fourier analysis; however, this involves a great deal of work, and since in the present problem the periods are close, this work can be greatly simplified as outlined in the following paragraphs.

The Fourier analysis was made for the period of one solar day with groups of days averaging about fifteen. Amplitudes



corresponding to periods slightly smaller and larger than one solar day and extending beyond the period equal to the sidereal day may be obtained by reference to the harmonic dial. If the maximum value of the function

$$f(t) = a \cos \frac{2\Pi t}{T} + b \sin \frac{2\Pi t}{T}$$

$$= c \sin \frac{2\Pi t}{T} + \Phi$$

where T is one solar day

is represented on a twenty-four hour clock dial by a vector, its length will indicate the amplitude, and its direction, the time of maximum. On the other hand, if this be done for a cloud of days, then the vector will indicate the mean amplitude and the mean time of maximum.

If the function f(t) is to be investigated for a period other than that represented on the face of the harmonic dial, then the vector for each partial cloud must be rotated through an angle depending upon the trial period. The amplitude c corresponding to the trial period T′ is given by the following set of equations:

$$a' = \frac{1}{n_s} \sum_{m=1}^{s} (n_m - n_{m-1}) \left[\begin{matrix} a_m \cos \alpha_m - \\ b_m \sin \alpha_m \end{matrix} \right]$$

$$b' = \frac{1}{n_s} \sum_{m=1}^{s} (n_m - n_{m-1}) \left[\begin{matrix} a_m \sin \alpha_m + \\ b_m \cos \alpha_m \end{matrix} \right]$$

$$\alpha_m = (n_{m-1} + n_m) \frac{\Pi T - T'}{T'}$$

where n_s is the total number of days analyzed ($n_m - n_{m-1}$) is the weighing factor and is the number of days in the mth group, and s is the number of groups.

After a suitable number of trial periods have been calculated the amplitudes may be plotted against the corresponding periods and this resultant curve is the periodogram. If peaks appear at the suspected periods these may be investigated as regards their reality by statistical tests of significance. Since the seasonal variation introduced a spurious sidereal period, this variation may be subtracted from the periodogram and the remaining portion may be investigated for a true sidereal variation.

One advantage of this method of analysis is that it is possible to obtain the

background of amplitudes. If the background of amplitudes about the periods investigated is of the same magnitude as that of the sidereal periodicity, no valid conclusion can very well be drawn concerning the realtiy of the suspected period. In the investigation which is being carried on in connection with the variation in intensity of cosmic rays, it is hoped that this method will give some positive evidence about the sidereal period.

THE EMISSION SPECTRA OF PLANETARY NEBULAE

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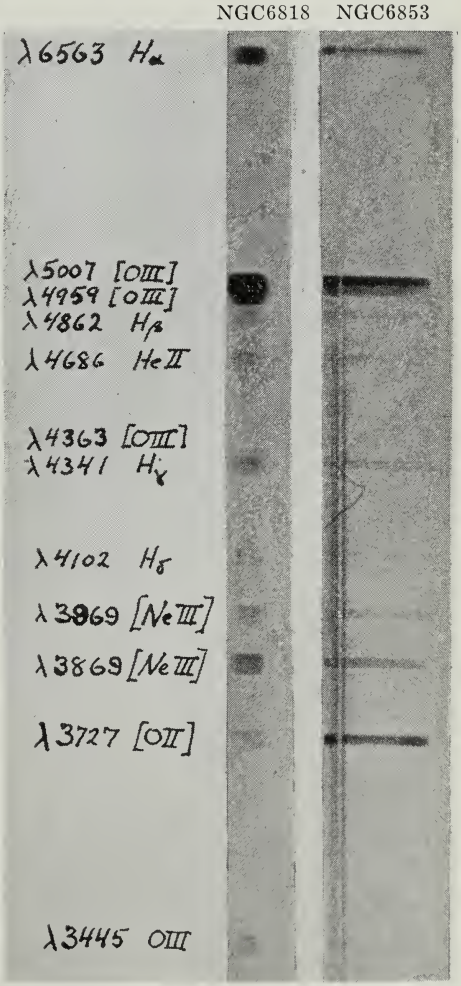
ABSTRACT

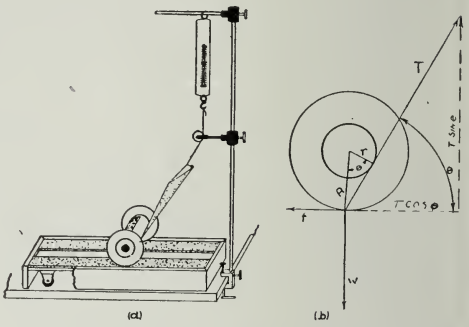
Photometrically standardized and calibrated wide slit spectra of 48 planetary nebulae have been obtained with the quartz Cassegrain spectrograph attached to the 82-inch reflecting telescope at the McDonald Observatory in Texas. The spectra on panchromatic emulsions are in good definition from λ 6563 to λ3133. Accurate intensities of the emission lines of *H*, *He I*, *He II*, [*O III*], [*O II*], *O III*, [*Ne III*],[*Ne V*], and of the continuous emission will be reduced from the spectra. From a preliminary examination of the material it has been possible to classify the nebulae of normal surface brightness (about 7 mag. per square minute of arc) according to the excitation shown by their spectra. High-excitation spectra show strong *He II*, stronger [*O III*] than [*O II*], and relatively strong continuous emission. There is a continuous sequence down to the low excitation spectra showing no *He II*, no continuous emission, and stronger [*O II*] than [*O III*]. This is a temperature sequence involving both the temperature of the nuclear star and the electron temperature in the nebula. The low-surface-brightness nebulae (about 11 mag. per square minute of arc) have strong [*O II*] as well as strong *He II* and do not fit into the sequence. Fig. 1 shows this effect on a 20-fold enlargement of one hour's exposure of the spectrum of NGC 6853 (the "Dumbell Nebulae", 12.7 mag. per square minute of arc) compared with a 4 minute exposure of the spectrum of NGC 6818 (7.3 mag. per square minute of arc). Pecularities are noted in the monochromatic images of several nebulae: in particular the λ3727 image of [*O II*]often shows quite a different structure of the nebula from the other line images.



A SATISFACTORY METHOD FOR MEASURING THE COEFFICIENT OF FRICTION BETWEEN RUBBER TIRES AND ROAD MATERIALS

V. F. Swaim, *Bradley Polytechnic Institute, Peoria, Illinois*

A short time ago Professor R. F. Paton of the University of Illinois presented a paper before the Illinois State Physics Teachers Association on a proposed "Friction Spool Experiment". It was suggested in that discussion that the friction spool could be used to determine the coefficient of friction between the spool and any material placed under the spool. It occurred to the writer immediately that the friction spool could be so constructed that one could determine the coefficient of friction between rubber tires and road materials. Two rubber tires, eight inches in diameter, were purchased and a wooden cylinder was turned to such a diameter that the tires would fit securely over the ends. One end of a strip of canvas was tacked to the cylinder, while the other end was attached to a wire hook so that a cord could pass from the hook under a pulley and be attached to a pair of spring scales hanging in a vertical position, as shown in fig. 1a. It was shown in Professor Paton's paper that there was an angle θ at which the tension T in the canvas could be applied so that the spool would slide on the surface under it instead of rolling. It was shown further that the condition of equilibrium when the spool was sliding required that the force of friction between the spool



and the surface under it, the weight of the spool W, and the tension T in the canvas must intersect in a point when represented by vectors, as shown in fig. 1b. It is easily seen from the diagram that the force of friction f is given by T cos θ, while the pressure of the spool on the road is given by $W - T \sin \theta$. Therefore, the coefficient of friction μ is given by

$$\mu = \frac{T \text{ Cos } \theta}{W - T \text{ Sin } \theta} \qquad (1)$$

Since it was desirable in this experiment to apply different weights to the road surface, a round hole was made along the axis of the wooden cylinder so that cylindrical weights of approximately

	W	θ	T	T Cos θ	T Sin θ	μ
	1740	61.3°	1350	648	1183	1.163
	2793	61.4°	2150	1029	1888	1.138
	3837	61.1°	3100	1508	2717	1.343
Glass	4906	61.1°	3900	1895	3420	1.277
	5945	61.2°	4900	2369	4295	1.435
	6998	61.3°	5750	2780	5041	1.420
	1740	61.3°	1350	648	1183	1.163
	2793	61.3°	2150	1033	1889	1.142
	3837	61.1°	3000	1448	2627	1.195
Wood	4906	61.3°	3800	1827	3330	1.159
	5945	61.5°	4600	2190	4040	1.151
	6998	61.4°	5400	2586	4742	1.148
	1740	61.3°	1250	601	1097	.934
	2793	61.6°	2000	950	1757	.916
	3837	61.6°	2750	1308	2416	.920
Concrete	4906	61.2°	3500	1684	3067	.915
	5945	61.5°	4250	2027	3734	.915
	6998	61.0°	5000	2423	4373	.923

1000 grams each could be placed along the axis of the spool.

It was also found desirable to place the road materials on a small truck provided with rollers so the road could be moved in a horizontal direction under the spool, as shown in fig. 1a.

Since the tires may flatten as the load is increased, the angle Θ may not be quite the same for all loads and should therefore be measured in each case.

The readings and calculations for a few road materials are shown in the following table.

THE PRODUCTION OF GEIGER-MULLER TUBES

Francis R. Shonka

De Paul University and W. M. Welch Manufacturing Co., Chicago, Illinois

Geiger-Muller counting tubes are used so extensively today that everyone is more or less familiar with them. However, there have been so many differing points of view on the actual operation of a counter, that we will discuss the discharge mechanism with a view to determine what comprises a good counting tube. The bibliography for the various ideas presented here would be too lengthy and hence no reference will be given.

Although the counting and recording circuits and even scaling circuits, where high speed counting is employed, have been developed to an entirely satisfactory degree, there still remains much to be desired in improving the technique for the production of tubes with good characteristics, and it is just this very difficulty that has limited their use.

The things that are definitely known about the action of a Geiger-Muller tube are that when a ray produces at least one pair of ions inside of the tube, a discharge will take place, and this discharge must in turn be stopped. The time of this discharge, together with the time required for the tube to recover sufficiently to register the next ray should be as short as possible.

Let us try to analyze the action taking place while a count is being recorded. It is only necessary for the ray traversing the tube to produce a single ion pair. The electron from this first ionization comes into the region of the central wire, which is at a high potential with respect to the cylinder. When the electron reaches this strong field it produces both positive and negative ions by collision with the atoms of the gas. The electrons are quite certainly the chief ionizing agent since the field in the neighborhood of the central wire is sufficient for the electrons to ionize by collision. Due to the fact that the mobility of the positive ions is much less than that of the electrons, the positive ions do not play an important part in this process. Each new electron will in turn create new ion pairs, so that the region of the central wire will become heavily ionized.

If this heavy ionization actually takes place, it must be accompanied by the production of photons. This can be visually confirmed by the fact that if one observes the tube in a darkened room while it is operating, a flash of light covering the central wire will be seen every time a discharge takes place. These photons at the center of the counter may again eject photoelectrons by absorption in the gas or the cathode of the tube. Many have considered these ejected electrons to play a most important part in the characteristics of a counter, and so they have attempted to reduce the effect of these ejected electrons by increasing the work function of the cathode or by coating the cathode with a high resistance material.

It seems reasonable that since the positive ions are less mobile than the electrons, there will be an accumulation of positive charges around the central wire. This will reduce the potential gradient until no further ionization even by the electrons can take place. The positive cloud then moves outwardly and reaches the cathode in about 10^{-6} seconds. On reaching the cathode these positive ions may or may not produce new electrons.

It seems that the so-called "self quenching" counters are those in which no new electrons are produced. Tubes in this class are those containing vapors, and tubes that have special coatings on the cathode. If, on the other hand, new electrons were produced at the surface of the

cylinder, the entire action might be repeated if the potential difference across the electrodes was at least equal to the threshhold voltage. The voltage across the tube will have been reduced by the migration of these ions by an amount depending on the quantity of charge transferred; the constants of the circuit; and on the amount of charge that leaked back to the electrode through the external high resistance. If the initial surge of ions reduces the voltage across the tube sufficiently then the discharge will be stopped even though new electrons be formed at the cathode. On the other hand, if this surge does not reduce the potential difference sufficiently a new surge of ions takes place, and each surge would reduce the potential difference and the action finally ceases when the difference of potential is reduced to a value below threshold voltage.

There have been many other ideas put forth concerning the discharge mechanism of a counter, but the ones which have been presented above seem to be the most reasonable ones. They also have been verified by experience to a large extent.

Thus to build a fast counter it is obvious that the whole discharge process should be completed with a single surge of the charges inside of the tube. This will be the case provided no electrons will be produced at the cathode when the positive ions strike the wall, as is the case in the "self quenching" type of counter. In this type of tube the vapor filled ones seem to be the most successful. The methods of filling these tubes are not critical, and it is possible to obtain practically one hundred per cent production efficiency. A good technique consists of evacuating the tubes with a force pump; filling them to a pressure of about a centimeter of mercury with some organic vapor, such as ethyl alcohol; adding about nine centimeters of mercury pressure of argon; and finally sealing them off. The way in which these vapor tubes are generally used is by connecting them to the source of potential difference through a resistance of the order of 10^5 ohms.

Another type of fast counter is one in which the potential difference would be reduced to a value below threshold voltage by a single surge of the ions. The technique that we have employed for a tube of this kind involves a thorough cleansing before assembling the parts of the tube. After the parts are assembled the tube is filled with cleaning solution for several hours, and then washed with distilled water. The tube is then pumped on a high vacuum system from ten to twenty hours at a temperature of over 500°C. This removes impurities especially from the surface of the glass. The copper cylinder is then oxidized and the oxide coat is removed with a dilute solution of nitric acid, in order to get the copper cylinder in as clean a condition as possible. After a thorough flushing with distilled water, the tubes are again put on the pumping system and baked for several hours. Commercial hydrogen is then admitted while the tube remains at the high temperature. This reduction is continued for about two hours, after which time they are evacuated and refilled with hydrogen through a palladium valve to about ten centimeters of mercury pressure. With this technique we have obtained tubes with plateaus of over a thousand volts having very good all-around performance. Due to the long plateau no stabilized source of high voltage is necessary. These tubes can be used at a very high over voltage, thus increasing the speed with which the ions multiply.

The tube is generally used with a Neher-Harper or a Neher-Pickering amplifying circuit which reduces the time required for recovery. We have found these hydrogen tubes to stay constant over indefinitely long periods of time. Some of our tubes, which were built five years ago, still function as well as when they were made. I do not know of any vapor tubes than can quite measure up to this performance. The chief drawback to this tedious technique for the hydrogen tubes is that the production mortality is very high.

There are other techniques used by investigators for building Geiger-Muller tubes, but in many cases these magic formulae seem to work only for the persons who devised them. The two techniques which have been considered in this paper are probably the most widely used.

THE ANALYSIS OF AN A. C. CIRCUIT CONTAINING R, L, and C

FRANK L. VERWIEBE
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The usage of the term, power factor, referring to alternating currents, is becoming increasingly common. Not only are motors recommended in terms of their power factor, but now the advertisements of certain brands of the newly popularized fluorescent lamps also refer to their high power factor. It was this latter fact that suggested a demonstration experiment in the beginning course of physics to make the analysis of an A. C. circuit as simple and clear as possible.

Fig. 1 shows the circuit used. The values of R, L, and C are so chosen that the current may be made exactly 1 ampere by adjusting R, a slide wire rheostat. This greatly reduces the later computations. The voltage leads of the wattmeter and the voltmeter leads are left free to be placed across the different parts of the circuit, as well as across the circuit as a whole. By joining these leads in pairs the manipulation of the experiment is facilitated.

Typical data are indicated below the figure. They include the power in watts, the voltage, and the current for R, L, C, and the entire circuit.

Fig. 2 shows the computations performed on the data. From the relation $W = VI \cos \theta = VI \times$ power factor, $\cos \theta$, the power factor, is first calculated. then $\sin \theta$ is found from trigonometric tables. The values of $V \cos \theta$ and $V \sin \theta$ are next computed. The vector diagram shown in the lower half of the figure is drawn to scale. A check of the work is provided by summing the appropriate vectors to find the resultant voltage. Its magnitude and phase angle in respect of the current should match within the limits of experimental error the values observed and computed for the circuit taken as a whole.

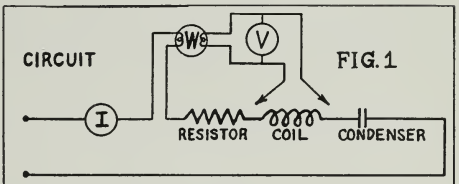

FIG. 1

DATA

	WATTS	VOLTS	AMPERES
RESISTOR	102	102	1
COIL	7	53	1
CONDENSER	5	39	1
WHOLE CIRCUIT	114	115	1

COMPUTATIONS

	W	V	Z	cos θ = W/VI	sin θ	V cos θ = R	V sin θ = X
RESISTOR	102	102	102	1.000	0	102	0
COIL	7	53	53	.132	.991	7	52
CONDENSER	5	39	39	.154	.988	6	38
WHOLE CIRCUIT	114	115	115	.991	.133	114	15

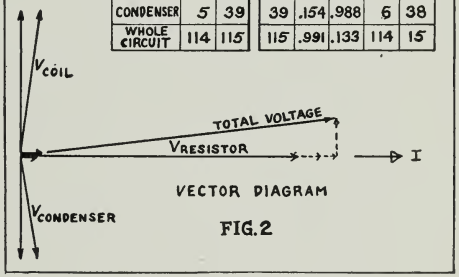

FIG. 2

If desired these data can also be used to analyze the impedence of L and C into reactance and resistance, so that the inductance and capacitance and power factors can be computed.

This experiment is followed by an individual experiment performed by each student, in which he measures the D. C. resistance and the A. C. impedance of an inductance coil. From these he computes the reactance, inductance and power factor of the coil.

Papers in Social Science

Extract From the Report of the Section Chairman

The first meeting of this new section in the Illinois Academy of Science was attended by about 20 and had four papers on this initial program. Two of these are herewith published. The others were:

Lathrop, H. O., *Illinois State Normal University, Normal*—The end of our public domain.

Wirth, Louis, *University of Chicago, Chicago*—Sociological research in Illinois.

It was decided to continue this section in future, and C. W. Schroeder, Bradley Polytechnic Institute, Peoria, consented to act as chairman for the 1942 meeting.

(Signed) D. E. Lindstrom, *Chairman*

THE SOCIOLOGIST IN A TIME OF CRISIS

Arthur J. Todd

Northwestern University, Evanston, Illinois

My feelings in undertaking a discussion of this topic are, to say the least, highly mixed. On the one hand I feel like the traditional fool venturing to rush in where angels fear to tread. On the other hand I feel like the pedestrian starting on a supposed voyage of discovery along a dusty highway, beaten down by centuries of earlier travelers. However, as good soldiers and good members of our craft, I am glad to join with my fellow social scientists in this discussion.

In the first place let us state that we are not unaware that other social scientists are studying this same problem. Only a week ago on this campus representatives of the National Social Science Research Council and of local councils from Massachusetts to California spent two whole days threshing out this very question. You will all remember Professor MacIver's presidential address to the American Sociological Society last December. The whole tenor of his talk was on this very subject of what the sociologist should do at such a critical period in our history. He referred to a committee of the American Sociological Society which was studying the problems of the nation in process of arming itself against crisis. You will recall also the report of the Sub-committee of the Executive Committee on Participation of Sociologists in the National Emergency Program, dated December 29, 1940. As a result of that report apparently a policy was adopted by the Executive Committee establishing a regular standing committee of the Society to work with the United States Civil Service Commission. Also, undoubtedly as a result of these same considerations, a committee drafted a very intensive questionnaire which was sent to all members of the Sociological Society asking them to list their qualifications and specific technical abilities which might be available to government in this particular emergency. Many of us filled out those questionnaires and returned them. The American Economic Association followed suit with somewhat similar questionnaires.

Partly as a measure of self defense the universities and colleges have become interested almost to the point of alarm over this attempt to mobolize actively sociological and other scientific talent for governmental service. And with good reason, because while, of course, it is understood that many sociologists have administrative and other abilities which could serve governmental purposes extremely well, nevertheless there are certain other functions of the sociologist which must be maintained on the college and university level if we are not to be caught in the swirl of emotional disturbance and forget the duty right at hand in the thrill of a contingent heroism on a distant horizon.

That brings me specifically to the point that I think the first duty of the sociologist. That is to maintain, right where he is, the spirit of sociological science above the clamant pressure of propaganda and prejudiced testimony. He must sustain the claims of disciplined intelligence in the field of social problems as against emotionalism. He must continue to nurture and to teach the necessity and power of convictions based on evidence.

It is essential that the teaching function be maintained during this period of crisis as an insurance against heat without light and the destructive passions which would engulf education and the nation itself unless properly safeguarded. Youth at our colleges and universities is a very tangible reality and demand, not a contingent but a very present realistic claim for public service. It is essential that students be taught now more than ever before the basic ideas of how to live with their fellow men. Remember Professor MacIver's challenge in his address last December—

"Men seem to learn every other lesson more quickly than how to deal intelligently, on the larger political scale, with

their fellowmen. I am not dreaming of any utopia in which conflict will cease. I am merely suggesting that much of the actual conflict is misguided and ruinous, because of a lack of foresight, a lack of understanding, such as men do not display in the conduct of their other affairs. And the understanding that is most lacking is the understanding that sociology should and can provide. For it is the understanding of social relationships, of the social values men cherish, of their tribal gods and idols, of their responses to controls, of their long-run reactions to indoctrinations, of the tides of opinion, of the constancy and fickleness of mass emotions, of the consequences to the ingroup of treating the outgroup thus and thus."

As a part of our academic responsibility and our citizen's duty it is essential that sociologists work for the maintenance of freedom of the mind, freedom of speech, academic freedom, and all other civic and constitutional rights. But in this struggle for maintaining these rights we must be intelligent, tolerant, discreet, and not provocative. We must be realistic as sociologists in recognizing the presence of the mores, of mental sets and traditional attitudes. We must avoid gratuitous offense and opinionated self righteousness if we are going to serve these rights and exemplify the spirit of tolerance. We have to remember both in our teaching and in our practice that rights are not absolutes, but relative privileges sanctified by experience. I have known intolerant defenders of tolerance just as I have known extremely militant pacificists. There is a big difference between the sincere and effective defender of constitutional rights and liberties and the mere fuss-budget.

Most departments of sociology are being urged to emphasize the training of students in practical administration, whether directly themselves or through cooperation with departments of political science and economics. These courses may be coordinated even in the absence of a definite social service or social work division. Short courses also may be organized particularly in recreation. During the first World War I operated two successive summers what we called Social Service Plattsburgs which included a series of two week intensive units of work in certain fields of social welfare effort. I also conducted special courses in Red Cross home service administration. To a certain extent the multiplication of social workers and the professionalization of social work in the last twenty years has perhaps rendered obsolete some of this type of educational work; but undoubtedly if the war crisis is actually precipitated and continues for several years as some observers predict, the strain on our various professional services will be greater than the present ranks of professional workers can sustain. It will be necessary to give intensive training of a sort to people who do not expect to be professionals, but who would, with the return of normal times, return to their voluntary status capacity.

From the standpoint of research, sociologists should be in a position to derive much worthwhile data to carry forward the practical significance of their science. For instance it should be possible to study more effectively than ever the ties that bind, the factors that make for social solidarity on the one hand, and on the other, to grade and rate more accurately the forces that produce tension and breakdown; to study the sources and workings of conflict as projected into army and navy, defense production, and the thought processes in local communities. There has been an occasional study of the effects of war upon the family, but not to the same degree that we have observed in the case of the depression. This is only one simple example of a field of research which, so to speak, is hot and will continue hot for the duration of this emergency. But I should also urge continuation of what might be called normal or non-emergency-inspired research, on condition of course that it is really significant and knows where it is going. This is no time for academic "busy work."

It goes without saying that sociologists, like other scientists and good citizens, stand ready to put their talents at the service of their communities as they have done in preceding emergencies. In order to offset the centrifugal tendencies of the national questionnaire to which I have already referred, local community authorities and the local colleges and universities need not only to mobilize the technical abilities of their faculties, but also see to it that defense and preventive projects right in their own areas are de-

veloped and made available for the sociologists of their faculties. There is much to be done in the field of recreation, in visitation of the families of draftees, in supplying the places of technical experts called away, in combating juvenile delinquency, in vocational guidance, in public health work, in the campaign against venereal diseases.

Finally, this is the time of all times when sociologists ought to be considering realistically the terms and conditions of a rational peace adjustment and the repairing of breaches in the social texture caused by war. Last week one night after going to bed I was suddenly stricken almost with panic over what I should do if by some chance called upon to work out a new pattern of living together in Europe and Africa or Asia. And I suspect that many of my sociological brethren would be in no less of a cold sweat than I was at the possible prospect. Yet they should prepare to figure at the council tables along with historians, politicians, economists, and military leaders. Their understanding of population problems, ethnic issues, social psychology and techniques of social control, the objective measurements and conditions for social progress, and the whole historical cycle of efforts at social improvement should entitle them to a hearing not only during the progress of hostilities but after overt hostilities are ended.

In short, the sociologists have the opportunity and the obligation to continue on an improved scale their teaching, their research, their participation in community betterment, and to make their science an effective element in what I may venture to hope will be a somewhat more rational arrangement of the world's contours and organization after this nightmare of world chaos and depression has become a thing of the past.

REPORT ON RESEARCH PROJECTS "IN PROCESS" IN SOCIOLOGY AND RURAL SOCIOLOGY AT THE UNIVERSITY OF ILLINOIS, 1941

D. E. Lindstrom
University of Illinois, Urbana, Illinois

Ahrens, E. A.:
Study on Social Categories
(The problem is to work out the basic social categories for the whole realm of human nature. The purpose is to achieve integration of parts now completely severed from one another and to lay the ground in terms of which social phenomena may be made intelligible.)

Albig, William:
—The Content of Radio Programs, 1925-1940
(A comparative study of various American and English stations. 1925-35 published. 1935-40 ready to publish.)
—A Study of the Trends in Cartoon Symbols, 1900-35.
—Trends in Content and Symbols of the Newspaper Comic Strips, 1900-35.
—Science as Reported in the Newspapers, 1910-35.

Fox, Sherwood D.:
Charisma and the Social Structure

Hiller, E. T.:
—Mid-Western Regional Organization as Disclosed by the Patterning of the Population (The manuscript is in process and is nearing completion.)

—Community Studies:
1. Process of Moving a Small Town (This study is in abeyance for the present. It is to be resumed at a later date.)
2. Value Orientation of a Rural Culture-Community (The manuscript is being prepared.)
3. Social Organization of a Pietistic Group (The manuscript is being prepared.)
4. Reorganization of a Community After the Closing of the Mining Industry (The research is a thesis subject of a graduate student.)
5. The Value Orientation in an Agricultural Village (The research is being performed by a graduate student.)

Hulett, J. E., Jr.:
The Comparison of Widely Separated Rural Groups by Means of an Attitude Scale Constructed by the Criterion of Internal Consistency.

Janes, Robt. W.:
A Study of the Moving of Shawneetown, Illinois:
An analysis of the sociological aspects of an attempt to move a town to a new site to escape dangers of flood.

Klein, E. E.:
—Community Resources for Social Welfare in Champaign County (A handbook especially for Social Administration students)
—Objective Examinations in Public Welfare

Mulvaney, Rev. B. G.:
Correlation Between "Catholicity" and Birth Rates in Germany and the United States (Doctoral Dissertation)

Powell, Martha:
The School as an Organization of Social Roles (Master's Thesis)

Price, Maurice T.:
Cultural Hybridism and Revolutionary Attitudes in the Modern Chinese Student Prior to 1925

Timmons, B. F.:
—Laws of the 48 States Directed toward Definite Economic Encouragement of Family Life (conducted by NYA students)
—Comparative Cost of Living for Young People Before Marriage and After Marriage (NYA students)
—Intra-family Relationships in Families of Step-parents (Conducted as a project among regular students of Sociology 5)

Tylor, W. Russell:
A thorough study of the nature and content of courses in Sociology, as being offered by the high school throughout the state, as these are developing in juxtaposition to other social science courses, exclusive of history, and as they may evidence certain social adjustments in the curricula and personnel of the institutions in question.

Williams, Helen:
Introvert Autobiographies in Different Cultures
(Graduate student, Sociology)

Yeatman, T. P.:
The Youth Group of the Southeast Region of the United States:
An Analysis of Population Trends in Relation to the Youth Problem.

Znaniecki, Florian:
The Social Role of the University Student
(Collective project:
a. Graduate Students: Brenton Brewer, Sherwood D. Fox, Barbara Klose, Ellen Nudd, Irene Pierson, Martha J. Powell, Lore U. Rasmussen.
b. 34 undergraduate students—(Juniors and seniors.)

In Rural Sociology

Lindstrom, D. E.:
—Indices of Human Welfare
—Human Element in Land Use
—Inventory of Rural Organizations
—How Rural Organizations Function
—Participation of Farm People in Rural Organizations
—Opportunities for Rural Youth
—Community and Neighboring Mapping

WORKERS' EDUCATION AND ITS IMPLICATIONS FOR VOCATIONAL GUIDANCE

ROBERT L. COOKE

Wheaton College, Wheaton, Illinois

Not all of those engaged in public-school education are well informed as to a very significant movement in recent educational history, that known as Workers' Education. By this we do not mean vocational or industrial education as such; rather it is an attempt on the part of the labor group in this country, particularly the labor unions, to develop a program whereby the workers themselves and their children may be educated in a way planned by, dominated by, and sympathetic to labor, and distinctly apart from the public-school educational program.

As a brief historical sketch, we may say that the movement began in this country soon after the turn of the century. In 1911, the National Women's Trade Union League initiated a labor school in Chicago, and in 1915 the International Ladies' Garment Workers' Union launched the first of their Unity Centers, of which there are now about fifteen in as many cities, with upwards of six hundred study groups and with about 30,000 attending.

In the early 1920's the American Federation of Labor adopted the movement, and brought it into their own organization by means of a "Workers' Education Bureau." Under this impetus, a development took place which has now resulted in more than fifty city labor colleges, many summer schools, as well as some elementary and high schools. Some of the newer labor unions are also seeing the possibilities in Workers' Education, and have established further schools on their own account. A recent large increase has taken place under the unifying program of the Affiliated Schools for Workers, which group has at least eighty local committees conducting schools throughout the country. It should be noted that though the curriculum and the offerings in the workers' classes are frequently similar in title to those in our public schools, they are usually vastly different in teaching method and in point of view.

It is true that public education has made some efforts at rapport with the workers, with a considerable measure of success in some instances. Witness the School for Workers in Industry at the University of Wisconsin and their Summer School for office workers, the Bryn Mawr Summer School, and the Pacific Coast School for Workers in connection with the University of California. Also the Federal Government through its Emergency Education Program, and using unemployed teachers, has at times had as many as 40,000 office, store and factory workers in classes.

But the workers themselves claim not to be satisfied with this help, nor to feel that these programs, good as they may be, meet the basic need. As one of their leaders said: "Labor is undertaking to educate *itself*, thus refusing to have education handed out to it by those who neither understand nor sympathize with its problems and points of view."

Although the labor forces, at the time of the agitation which resulted in the passage of the Smith-Hughes Act and the development of the vocational program in our secondary schools, took a prominent part in that effort which resulted in the establishment of industrial education in high schools, they have since become cold and in many cases antagonistic to it. The reason for this antagonism and in fact for their insistence upon the maintenance of a separate and complete workers' educational program has been explained by one of themselves thus:

"It is unreasonable.....to expect the teachers in the lower and higher schools to understand or admit the special educational needs of the workers as a class. The nearest approach to such an understanding has occurred in vocational education with well recognized results. Here the recognition of the special educational needs of the workers as an economic class is so complete that the curriculum fails to consider the possibility of a removal from that class....The public schools fail to grasp the idea that true

education means, first, training to earn a living; second, preparation for promotion; finally, and more important, instruction in the possibilities and methods of participation of all workers in the management and forming of financial policies of the industries in which they work." In brief, the worker, in his own words wants "not education for culture, but education for control".

A very significant development of recent years has been the rather general introduction of communistic elements into the management and the curriculum of a large number of the schools. Many of these schools have recently been disowned by the more conservative labor leaders, which has tended rather to exaggerate than to reduce this trend, in the thinking of many concerned.

Now what are we to say of the significance of such a movement as this, even granted that it has not been as successful and as widespread as its early promoters had hoped? Surely it is important for the educational and vocational counselor to see the implications of a development like this. Is not such a counselor remiss who undertakes to attempt to make vocational and educational adjustments for the children of the laboring group, and who is at the same time ignorant of the fact that the parents of these children may be all the while imbuing them with an outright if not contemptuous disapproval of the whole present public-school system? For we must face the fact that a considerable number of those who comprise in total more than half the school's population—the industrial workers of America—subscribe to an educational philosophy diametrically opposed to the thinking of the educators now in control of our public schools. Would it not be wise for those of us interested in vocational guidance, in fact for all of us in education, to take into account this undercurrent of disapproval, this striving toward something not satisfied by our present school system? Is it not time, in fact, to take stock of our complete educational system and its philosophical bases, to learn whether the present program is one which we can with perfect confidence claim to be a satisfactory offering for all the children of all the people? If this be done, and it has been done,* we may perchance find valid criticism of the basic philosophy of present-day education much more far-reaching than that given by Workers' Education.

* See Robert L. Cooke, *Philosophy, Education and Certainty.* Zondervan (Grand Rapids), 1940.

Papers in Education and Psychology

Extract From the Report of the Section Chairman

The Evanston program carried nine papers and a symposium led by Robert C. Woellner, University of Chicago. Six papers are herewith published. The others were:

Cavan, Jordan T., *Rockford College, Rockford*—Some roots of vocational education.

Cloud, Daniel T., *Illinois School for the Deaf, Jacksonville*—Vocational guidance for deaf pupils.

Melrose, J. A., *James Millikin University, Decatur*—Factual maps to guide personnel guidance.

Eighteen attended, and elected as chairman of the 1942 meeting J. M. Hughes, Northwestern University, Evanston.

(Signed) O. Irving Jacobsen, *Chairman*

ATTITUDES IN SCHOOL ADMINISTRATION

J. M. Hughes

Northwestern University, Evanston, Illinois

In recent years, social psychologists have given attitudes a most significant place in their attempts to develop a more acceptable understanding of human conduct. Some of them, the more renowned, in fact, such as Mead and Allport, have used attitudes as a sort of central theme to their sciences. That they have enabled us better to understand the processes of human behavior, there can be no question. On the other hand, there is little evidence that the knowledges developed by them have penetrated as far as they deserve and as rapidly as they merit into other fields. Especially would it seem that their materials have wide application to school administration, because school administration is itself, a social field. While it is impossible to dwell long upon the general applicability of a theory of attitudes to school administration in a brief article, one can present the point of view of the social psychologist and can then analyze some of the problems of school administration in terms of it.

It is the contention of the social psychologist that an understanding of attitudes seems essential to an understanding of human behavior, since they form the background out of which a given individual or social act emerges. Naturally, the most satisfying way of explaining an act would be to do so by directly identifying it with the physiological process in which it originates and out of which it develops. Obviously, in the present state of knowledge, this is impossible. We can closely approach this method, however, by identifying the act as attitude. An attitude may represent various organizations of parts of the nervous system *which are going to be responsible for acts.* These hypothetical organizations we recognize under the appellation of attitudes. In this way of looking at behavior, attitudes constitute a form of behavior potential which will be influential, at least, in shaping the character of the individual act in its initiatory stages.

School administrative theory as it has been developed in this country seems to have lived apart from these knowledges and interests of the social psychologists with respect to behavior. Much of it has been channeled in a course which runs counter at many points to the beliefs of the social psychologists in general and runs counter almost at every point, in particular, to which social psychologists believe to be true of attitudes and of the significant part they play in problems of human relations.

If attitude is as potent a factor in shaping the character of the social and individual act as social psychologists believe it to be then it would seem that school administration must become more concerned in the future than has been true in the past with taking it into account when problems of human relations are being dealt with. Not only must administrators be able to identify attitudes but they must be able to effect desirable changes in them. This holds for their own attitudes as well as for the attitudes of others.

Probably the most effective way to study attitudes is by the method of direct observation by a skilled observer of each individual person. It seems doubtful that they can ever be satisfactorily measured. Assuming that they could, the problem of predicting the bearing each would have upon an individual act would still not be a simple one. Obviously, mass study by self identification of attitudes has serious weaknesses. On the other hand, the method possesses at least one good feature. It permits the rendering of a generalized judgment by a group of people with respect to what they conceive their attitudes to be toward certain specified items. This thereby makes possible certain general conclusions with respect to how conditions should be changed if we wish to eradicate or to intensify such attitudes. Thus, it directs attention toward factors which operate to build or destroy attitudes in people.

The way in which an understanding of

attitudes could affect school administration was impressed upon the writer by several studies he has made in the past in the field of supervision, particularly by the results of one of the studies[1] published two years ago.

The method was that of mass, self-identification. We may draw upon some of the findings of that study for examples of administrative practice which make for good and bad attitudes. Let us first list practices which, for most people but not for all, result in attitudes which have an antagonistic quality. They might be itemized as follows:

1. The practice of having superior officers rate teachers.
2. The practice of superior officers of giving negative criticisms after seeing a teacher teach.
3. The practice of helping a teacher to employ a particular method of teaching.
4. The practice of having teachers plan without in some way providing an organization which will enable plans definitely to become action.
5. The practice of having schools organized into departments and having each department administered by a head.
6. The practice of organizing the school around numerous functionaries.
7. The practices of class-room visitation, and visitation followed by conference.
8. The practice of having regular classroom teachers do demonstration for their colleagues.
9. The practice of holding regularly scheduled faculty meetings.

The attitudes toward these practices as held by most teachers and administrators included in the study were distinctly antagonistic. Yet these practices are among the commonest employed in the whole field of administration.

Certain practices, in the main, arouse favorable attitudes. Among these are the following:

1. The practice of giving constructive suggestions to teachers which lead to improvement in teaching.
2. The practice of giving active aid to groups of teachers who are planning or carrying out some joint endeavor the results of which promise to bring general professional improvement to those participating.
3. The practice of allocating the supervisory function to one person in a school, to one person alone and with the understanding that supervision is to be his sole function.
4. The practice of having teachers act as chairmen of subject matter groups, (as opposed to having superior officers act as heads).
5. The practice of having planning done by small groups and of having meetings held by small groups, the groups to be formed on the basis of homogeneous interests.
6. Practices such as:

a. helping a subject group to plan some group study or project as a result of which the teachers will be able to proceed more intelligently.

b. providing groups with educational data and information, the need for which has grown out of the work for the group.

c. making available certain professional articles and studies which bear upon educational topics being discussed by teachers.

If, as we said at the beginning, attitudes form the soil out of which an individual or social act emerges and in terms of which the complete act is developed, a mass study of attitudes, despite the admitted weaknesses of the method, leads to the feeling that a number of points in school administration are needful of serious consideration. Three of these seem to stand out more prominently than some of the others.

The first of these is that certain of our administrative methods will need to undergo change and some of the devices now in common use may well be discarded. Thus, everyone knows that inspection of individuals or of institutions is almost always resented. No one would inspect an institution unless he were paid to do so—fifty dollars a day and expenses. Like the judge in traffic court, the inspector works for the fees he gets. It could readily be shown that the inspection function if we only cared to do so could be handled with different results. As to rating devices, their use is now on the decline. The effect of their use in terms of the attitudes they caused to be

[1] J. M. Hughes. *The Attitudes and Preferences of Teachers and Administrators for School Supervision.* Northwestern University Contributions to Education, School of Education. Series No. 12. Evanston, Ill., 48 pp.

built was definitely bad. Careful selection of teachers, indefinite tenure, automatic salary scales, stimulating teaching environments can completely abolish the need for rating scales.

The second is, that our methods of handling problems of human relations will need to be more consistent in the future with those knowledges and insights of social psychology which dictate the methods to be used. For example, many of the methods now used ignore almost completely the knowledge about emotion and its relation to adjustment and development. Some of the methods simply ignore the harm done when by their use, irrelevant or strong emotions are aroused or worry and strain are introduced.

The third is that organizational patterns will have to be set up which are less, much less, static than those which obtain at present. The principle need of organization, at present, seems to be the incorporation of factors and elements which make change in organization a natural characteristic of organization itself. This, too, is possible as is shown by the successful operation of a number of present day organizations.

It would seem, then, that administrative theorists should not continue to advocate that administrators act in a direction which opposes the movement of the social forces observable within a staff. Attitudes furnish good cues to the direction and the magnitude of these forces, and enable one to know toward what the forces are directed. It is not easy to brave the forces of a torrential stream. Such knowledge, however, should aid us to act more intelligently, provided of course, we seek to act in ways consistent with such knowledge.

GUIDANCE TESTING

O. Irving Jacobsen

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This field has grown to such proportions that it is impossible in a short paper to include the great scope which it embraces. There are a few important problems which should be considered, even though some of them have not as yet been solved. Progress is being made rapidly, and the prospects point toward a scientific and efficient development in this phase of administrative work in high schools and colleges.

Many educational institutions have, over a period of years, developed guidance clinics, which have become outstanding in their work, and have gained a reputation of efficiency and achievement. Some clinicians have compiled and devised their own tests to serve their special purposes. Experimentation is still going on, which is likewise an indication of progress.

The first question arising when a guidance clinic is about to be established by an educational institution, is that of the specific tests which should be given to students. Is it possible to give too many tests? Is it possible to obtain too much information about the students? It certainly is possible to give too few tests, and to have too little information about students, in order to give capable guidance. The questions seem, therefore, not to limit the amount of information desirable, but rather, the use made of such information when it is available.

A cumulative record, which includes a case study of each student, seems necessary. The misinterpretation of test results and other information can become a danger to the guidance program. This indicates the demand for a qualified specialist to head the guidance clinic, so that there will not be the danger of the program being "lost in a haze of tests." It would be a definite advantage if the clinician is well-informed in the field of mental hygiene, in addition to other regular qualifications.

The guidance program is all-inclusive so far as the faculty members are concerned. Although the clinician has direct control of the program, responsibility for its fulfillment rests with the entire teaching staff. Cooperation is necessary, since much information concerning

students is obtainable only from individual teachers.

Perhaps one of the first tests to be considered in a guidance program is the intelligence test. On the basis of a reliable test, essential advice can be given as to the education of the student. Perhaps the student should be encouraged to attend college, or discouraged. It may be that the student should be discouraged to complete high school, and to study some trade in a special school. Many cases can be cited in which parents have insisted that their child study for a professional career, against the advice of a guidance counselor, only to fail completely in his studies, and be forced to choose another vocation, after having needlessly wasted two or three years. It must always be remembered, however, that intelligence tests are not infallible, and also that they cannot measure effort nor ambition.

Achievement battery tests, or individual achievement tests in specific subjects, have a place in most guidance programs. On the basis of ability shown by these tests, educational, as well as vocational guidance can be given. These tests may also be used for prognostic or diagnostic purposes, depending on their contents.

The tests which are of prognostic nature are increasing continuously. While these tests are often given before college entrance, some of them can be given to advantage at any time. These specific tests include the fields of music, art, home economics, and general vocational aptitudes.

Nearly every clinic gives at least one test of character or personality. Certain vocations demand a special type of personality. It may be that a certain personality type would mean failure in a specific vocation. Therefore guidance in vocational choice is aided by knowledge of the results of a personality test.

The diagnostic tests are usually considered as belonging to the elementary school only. However, recently such tests have proven to be a great advantage in guidance. This has been true in the field of reading, where diagnosis may indicate a lack in earlier training, and through proper remedial training, it may be possible for a student to attain skill, and perhaps even surpass the average college or high school student in reading ability.

Some institutions have established special reading clinics, because of the need among students. In one college, it was discovered, by means of a reading test, that over fifty per cent of the first-year students had only eighth grade reading ability. Training to overcome this lack might end further difficulty for certain students, especially when they show no lack in other fields. There are some authorities, however, who question the duty of guidance work in the field of remedial training.

Since reading is essential for most high school and college work, faulty habits are a distinct hindrance to progress. A common fault found among students, is that of using oral reading habits in silent reading, that is, pronouncing each word "mentally." This procedure retards reading and hence it hinders a student from obtaining a higher score in any test in which reading is required. The author correlated the reading test scores of one hundred Freshmen with their English Placement test scores, and obtained a coefficient of correlation of +.96, P. E. .02. Reading and intelligence scores for this same group gave a correlation of +.95, P. E. .03.

Vocational aptitude tests are sometimes considered the most important, or the only tests with which guidance counselors should be concerned. Some of the tests in this field are still very much in the experimental stage, that is, their reliability has not yet been proven. Among the vocational tests now available are: dexterity tests, specific interest inventories, occupational questionnaires, and clerical and mechanical aptitude tests. The personal history rating chart is listed also as a vocational test.

Results of these tests can be used as a guide in advising students to enter or to avoid certain vocations. This makes further demands on the guidance clinician, that is, a thorough knowledge of what is required in the various vocations. The interest inventories are seldom reliable, since interest is often fleeting with students, and again, the test may be taken with student intention to check all that he knows belongs with a certain vocation which he intends to enter. However, since his knowledge is limited, his vocational choice may not coincide with interests of the choice.

In addition to the tests mentioned for guidance, educational and family history are of aid to the clinician. Knowledge of the student's health also is of aid in vocational guidance. Emotional adjustment likewise should be known. Sometimes the personality test includes both health and emotional adjustment.

The field of guidance testing is very wide, and since there are so very many tests available in this field, there may be the danger of including tests which are not valid measures of what they claim to measure. The guidance clinician must therefore have a thorough knowledge of tests, of testing techniques, and of test interpretation, and he must be on the alert for any new ideas and tests which can be of use in his field.

A VOCATIONAL PHILOSOPHY OF LIFE

George B. Lake

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What do people want from life?

That is a basic, vitally important, intensely intimate, and wholly individual question, which shockingly few people have ever taken the time and thought to answer clearly and intelligently; and the ignorance, shortsightedness, and mental inertia which are to blame for this deplorable condition make up one of the main things the matter with us today.

The average person is a good bit like the man who wandered up to the ticket window in a railway station and murmured, "I'd like a ticket, please."

"What station?" barked the busy clerk.

"Well, what stations have you?" inquired the undecided one.

If you think that's a funny story, try asking ten or twenty young people, and an equal number of those who are not so young, without any preamble, "Just what are you planning to do with your life? What do you think you are here for?" and note their reactions carefully and thoughtfully.

I will venture to say that, if you will carry out that experiment, as outlined, that story will not seem funny to you any more, for you will see it as a tragic allegory of millions of pointless lives, which are so because they are not based upon a sound philosophy.

Science asks but one question of the universe—"How?" And all our laboratories and research institutes, through all the years, have answered only a tiny fraction of that question; but as fast as they have formulated their fragmentary answers, philosophy has seized upon them and propounded the truly fundamental question, "Why?" Without the answer to that interrogation, the findings of science are hollow and ephemeral, for they do not go back to the place where things *begin*.

A poet, who was also a philosopher, once said, "Only the intangibles are sure."

Don't take his word for it. *Test* it by the standard of your own experience, and then you'll *know* whether he was right. What *lasts?*

The money a man earns in any skilled trade or profession may be lost or wasted in a wide variety of ways; but the *skill* that earned it lasts as long as his physical body holds together—and *long after that*, for skill is a manifestation of energy, and energy is indestructible, though it may change its form.

A house may burn to the ground and cease entirely to be a *house*, though its physical elements are not destroyed; but the *dream* of that house, in the architect's mind, is not lost. He can reproduce it, every beam and window and brick. That *lasts!*

Follow through along this line, with your own illustrations, and when you are convinced, out of your own knowledge, that the poet-philosopher was right, you will recognize that no vocational study, or any other activity in life, can be of any real and permanent value unless it is based upon intangibles. Of course all purely physical activities are absolutely conditioned by those universal intangibles that we call "the Laws of Nature."

The only "original sin," and the obstacle that man has been striving, for

millions of years, to overcome, is *ignorance.* We have made some headway, but not nearly so much as most people like to believe. The road ahead of us is far longer than the rough little stretch that is behind.

But that need not discourage us, for an exceedingly small number of us possess more than a minute fraction of the intangible (but utterly *real*) knowledge that is *now available*, so that we can profitably employ several lifetimes in catching up with what is *now* known, without considering any new additions that may be made to the total in the meantime.

The first foundation-stone of a rational and workable life philosophy is the recognition and acceptance of the idea that, behind all of the facts that we know about this completely law-governed (and therefore *intelligently operating*) universe, and all its manifestations that we can *observe* (though we may not understand them), there *must be* an incalculably vast storehouse of power and knowledge which we have not yet tapped, and an inconceivably fertile and forseeing Intelligence directing it all, which we may call God, or by any other name that suits us best.

Many seem to feel that, along this line, intelligently directed study is impossible or would be futile. Time does not permit me to go into this matter at length, but I assure you, of my personal knowledge, that such an idea is erroneous. The constantly growing literature in this field is already large and varied, and the opportunities for personal experimentation are practically limitless. The thoroughly scientific investigations of extrasensory perceptions, which Dr. J. B. Rhine, of Duke University, has been making during the past few years, are only the first short step, under "Orthodox" auspices, but sincere and industrious individuals have gone much further.

There is an old tale about an interested and curious traveler who came upon a group of men busily shaping masses of stone into regular blocks. He accosted one of them with the question, "What are you doing, friend?" The man looked at him blankly, wiped the sweat from his forehead, and growled, "Earnin' a measely six dollars a day." To the same question another replied, scarcely raising his eyes from his work, "I'm cutting nice, square blocks of stone for the masons." A third, similarly interrogated, raised his eyes to the clouds sailing over and whispered, "I'm building a cathedral, sir."

There, if you will study it a bit, you will find sketched the entire intangible (and therefore enduring) philosophy of all vocational effort, and it is on this foundation that we must build the vocational structure of the future.

The first question that one must ask, in connection with a vocation (and *answer*, clearly, directly, and with intelligence) is, "What do I truly *want* to do, above all other things?" The second is, "Just what *equipment*, tangible and intangible, will be required for doing this work?" And the third is, "Do I now possess such equipment, or am I ready and eager to spend the time, effort, and money to acquire it?

The answer to the first question is intangible (involving *ideals*) and *basic*, and unless it is sharply formulated, in detail, the others cannot be answered. If it is so formulated (which is pitiably rare), the answers to the two others will determine whether the individual will pursue his first choice, or will be content with a second, third, or twentieth, and this is a matter involving *character* (another intangible).

The individual wholly without ideals is or becomes a hobo, a "bum"; from those whose ideals are few and easily attained are recruited the millions of W.P.A. workers and satisfied recipients of government doles. No amount or type of vocational guidance or training will "take" on a person who has no ambition, no standards, none of that divine and intangible *afflatus* which makes featherless bipeds *men.*

Among those who appear to be in this unpromising category there are some who will work out of it if the intangible and wholly subjective quality or condition called *interest* can be stimulated by some internal or external circumstance, over which outsiders have but slight, remote, and indirect control. The change in outlook, if it is to be permanent, must be self-generated.

This change has been brought about, in many, by "exposing" them to the ideas that the laws of evolution and of cause and effect operate throughout the universe, at all levels of consciousness, and eternally, so that every man, at any par-

ticular moment, is the mathematically exact product of *his own* activities during his cosmic and finite past, and there are no such things as punishment or reward, but merely the impersonal and inexorable *results* of causes set in motion, at some time, by the man, himself.

On this basis it is evident that, not only must every one of us *pay*, in one way or another, for all he gets out of life, but also that we can *have* out of life anything for which we are willing to pay in the medium of exchange suitable to the nature of our ideals, which is rarely money, but far more often time, unremitting effort, physical self-denial, and other intangible units of value.

We are here in life for the intangible purpose of *growing* or evolving, as human souls, by developing such rudimentary faculties and powers as we possess through exercise; by gaining knowledge and transmuting it into *wisdom* by putting it to work and studying the results; and by learning to understand other people, so that *sympathy* may grow into impersonal or divine *compassion*, as we become able to function at higher levels of the universe, which is inseparably *one*, in all of the four dimensions in which we are now working, and so far beyond that that we are now totally unable to conceive of it.

Sketched thus briefly, this sounds like a decidedly tenuous and unsubstantial doctrine, but any one who is willing to *pay*, in time and effort, for more detailed information, can get it. The fact that it is worth what it costs is shown, pragmatically, by its tangible results in the material world.

If our present system of loaves for loafers, which permits idlers to subsist on a low level, at the expense of industrious citizens, were to be abolished next week, its supposed beneficiaries would discover that they had paid an excessively high price for eating without work, in the loss of the *ability* to work productively.

Among the voluntary workers, the lowest wages are paid to those who work with their bodies *only*, and the scale of remuneration rises in direct proportion as they add to their working machinery the intangible emotional, mental, and intuitional faculties, so that the highest financial returns of all go to the men who, transcending even intellect, rise to those rarefied heights where only *geniuses*, in industry, commerce, the professions, and all other fields, can breathe. And all the way up, the progress is steady, regular, orderly, and *step by step*.

When a sufficient measure of this philosophic viewpoint has been attained (consciously or unconsciously) to permit a man or woman to dream the dreams that are the necessary precursors of all accomplishment, such an individual will be eager to learn how his dreams can be objectified, and at this point, but not before, vocational guidance and training can begin to perform their beneficient functions, the first of which is to stimulate and assist the candidate for self-motivated advancement in *formulating* his aspirations in clear-cut detail, which is, by far, the hardest part of the *steady* progress on an *uphill road*, which is *education*, in its largest sense.

With the goal clearly in sight, the climber, with such assistance as we can give him, must make as objective and impersonal an *inventory* as is possible of his physical, emotional, intellectual, and spiritual assets and liabilities, so that he can determine what excess baggage of habits, prejudices, superstitions, and the like must be jettisoned, and what supplies and equipment for the journey before him he lacks, so that he may set about procuring them.

Here intelligent, experienced, and deeply sympathetic helpers can give invaluable assistance, if they can divest themselves of an obvious sense of superiority and of the urge to preach, and bring into play that near-divine faculty which the psychologists call *empathy*.

The elements of a sound vocational philosophy of life may be outlined as:

1. The vital realization that every human soul is a part of an inescapable evolutionary scheme that will carry him forward; but that he can increase the speed and ease of his progress by *learning how it operates* and then *cooperating* with it, *consciously*.

2. The clear perception and definite formulation of an individual objective for this lifetime.

3. An eagerness to attain that objective which will make any labors and trials involved in the process seem inconsequential.

4. A cool and impersonal inventory of one's *total* assets and liabilities, followed

by intelligent and considered action upon its results.

5. The acquirement of wisdom through employed knowledge; of faculties and powers through disciplined and continuous exercise; and of loving sympathy through observing, understanding, and helping other people.

6. Recognition of the fact that the index of any man's value to society (and therefore to himself) is the degree of his ability to *cooperate* and *contribute*.

STUDENT PREFERENCES IN DIVISIONAL STUDIES AND THEIR PREFERENTIAL ACTIVITIES

K. S. Yum

University of Chicago, Chicago, Illinois

What are the relationships between what college students prefer to do and their divisional choices in study? Are there any divisional differences in the activities which they prefer? Are men and women alike in these respects? These are questions which college deans, professors, and student counselors, as well as students themselves, would be interested in knowing. The present investigation attempts to answer some of these questions by means of the Preference Record of Dr. G. Frederic Kuder (6). The Preference Record lists seven major types of activities, namely, scientific, computational, musical, artistic, literary, social service, and persuasive. The lists of occupations for each of the seven major types are quite extensive (5). The characteristics of these preference items have also been evaluated (7).

The test was given to 193 juniors in the University of Chicago, and their preferential choices in the divisional studies have been investigated. The results are presented in Tables I to VII, in terms of sigma units.

Conclusions

1. The mean profile of the total group, presented in Table I, is significantly higher in the order of the social service, scientific, artistic, and musical activities, and significantly lower in persuasive activities, as compared to the norms. We might look upon this profile as a sample of university life on the motivational level.

2. Divisional differences seem to exist. The significant differences in the mean profiles of the Biological and Social Sciences are in the scientific and literary activities, as shown in Table II. Comparison of the three divisions of Physical, Biological, and Social Sciences, in respect to men, and comparison of the two divisions of Biological and Social Sciences in respect to women, bring out these differences more clearly and consistently as presented in Tables III and IV.

3. Tables V, VI, and VII in our data, show rather marked differences between men and women in some major types of their preferential activities, and indicate

Table I.—Mean Profile of the Total Group

Group	Number of Cases	Scientific	Computational	Musical	Artistic	Literary	Social Service	Persuasive
Total Group	193	.248	—.002	.196	.203	.038	.554	—.215

Table II.—Comparison of the Mean Profiles of the Divisions of Biological and Social Sciences (Men and Women Combined)

Divisions	Number of Cases	Scientific	Computational	Musical	Artistic	Literary	Social Service	Persuasive
Biological	59	.813	.308	.144	.366	—.521	.687	—.434
Social	87	—.226	.244	.041	—.014	.439	.531	—.060

Table III.—Comparison of the Mean Profiles of the Divisions of Physical, Biological, and Social Sciences (Men)

Divisions	Number of Cases	Scientific	Computational	Musical	Artistic	Literary	Social Service	Persuasive
Physical	18	1.517	.281	.703	.164	—.469	.056	—.603
Biological	32	1.203	—.323	.133	—.080	—.628	.434	—.275
Social	54	—.206	.324	—.069	—.290	.426	.301	.200

TABLE IV.—COMPARISON OF THE MEAN PROFILES OF THE DIVISIONS OF BIOLOGICAL AND SOCIAL SCIENCES (WOMEN)

Divisions	Number of Cases	Scientific	Computational	Musical	Artistic	Literary	Social Service	Persuasive
Biological	27	.350	—.291	.157	.894	—.394	.987	—.622
Social	33	—.259	.114	.223	.438	.461	.908	—.486

TABLE V.—COMPARISON OF THE MEAN PROFILES OF MEN AND WOMEN

Sex	Number of Cases	Scientific	Computational	Musical	Artistic	Literary	Social Service	Persuasive
Men	111	.479	.110	.139	—.131	—.035	.256	—.007
Women	82	—.064	—.152	.273	.656	.137	.958	—.496

TABLE VI.—COMPARISON OF THE MEAN PROFILES OF MEN AND WOMEN IN THE BIOLOGICAL SCIENCES

Sex	Number of Cases	Scientific	Computational	Musical	Artistic	Literary	Social Service	Persuasive
Men	32	1.203	—.323	.133	—.080	—.628	.434	—.275
Women	27	.350	—.291	.157	.894	—.394	.987	—.622

TABLE VII.—COMPARISON OF THE MEAN PROFILES OF MEN AND WOMEN IN THE SOCIAL SCIENCES

Sex	Number of Cases	Scientific	Computational	Musical	Artistic	Literary	Social Service	Persuasive
Men	54	—.206	.324	—.069	—.290	.426	.301	.200
Women	33	—.259	.114	.223	.438	.461	.908	—.486

that these differences are quite consistent. Women are significantly higher than men in artistic and social service activities; men are significantly higher than women in scientific activities. It is interesting to observe that women are more definitely uninterested in persuasive activities than men.

4. These profiles of motivation obtained here are not measures of ability but are meant to give some index of the extent to which an individual will be motivated in various areas along with the abilities at his disposal. Hence, they should be useful to those educators who are confronted with the problems of handling student counseling more efficiently.

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Papers in Zoology

Extract From the Report of the Section Chairman

The Evanston program carried 18 papers, and two symposia with three papers each: one symposium on "Animal Geography of Illinois," and one on "Endocrinology." Of all the papers read, 15 are being published in this issue, and three were published in the September issue by invitation. The others were:

Barden, A. A., *Northwestern University, Evanston*—Analysis of activity of the lizard.

Calhoun J. B., *Northwestern University, Evanston*—Analysis of banding of the chimney swift at Charlottesville, Virginia, and Distribution and food habits of the mammals of Reelfoot Lake region.

Carpenter, Charles K., *Baileyville, Illinois*—The family life of the Least Bittern.

Furrow, Clarence L., *Knox College, Galesburg*—Abortive ovogenesis in *Valvata tricarinata.*

Hawkins, Arthur S., *State Natural History Survey, Urbana*—Water fowl.

St. Amant, Lyle, *Northwestern University, Evanston*—The effect of castration and treatment with ethinyl testosterone on the development of the gonopodium of *Gambusa affinis.*

Thompson, David H., *State Natural History Survey, Urbana*—Fishes.

Wright, Bertrand A., *Oak Park, Illinois*—A quantitative sampler for aquatic vegetation.

About 120 attended the two sections and elected as chairman of the 1942 meeting Orlando Park, Northwestern University.

(Signed) W. V. Balduf, *Chairman*

THE INTRODUCTION OF WILD LIFE INTO SOUTHERN ILLINOIS

Clarence Bonnell

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ABSTRACT

Wild life in Illinois as our fathers and grandfathers knew it has almost vanished. Passenger pigeons, prairie chickens, wild turkeys, deer, buffalo, and the countless nests of song birds that one found in every hedge and apple tree are gone or remain only as remnants. Wild life in Illinois is a shadow compared with conditions fifty years ago and a tradition as compared with 1841. Comparatively recent attempts have been made to replenish this waste of our natural resources.

Two government agencies have undertaken replacements of the losses in Southern Illinois, beginning with State action many years ago. Illinois distributed 51,000,000 fish in 1939, 46,000 quail and 57,000 pheasants. The State Department of Conservation, according to its 1940 report, has produced 108,082,125 game fish of seven species distributed from 1935 to 1939 in bodies of water numbering up to 1107 in 1939.

Twenty-five years ago, prairie chickens were frequently seen from the railroad trains in passing through Hamilton County which is in the third tier of counties north. I have been over that county frequently in the past ten years and I have noted but a half dozen pheasants and one prairie chicken.

The Illinois Division of Conservation had $483,493 on deposit in its Game and Fish Fund December 31, 1939. I cannot agree with the statement in its 1940 report that, "This fund belongs to the sportsmen of Illinois," although the total sale of licenses for the biennium 1937-1938 amounted to $1,451,497. The sale of 751,381 such licenses in 1939 does not necessarily mean that wild life is increasing as the report seems to imply. The report says, "This artificial production of wild life by the department materially aids natural propagation and insures more game for those who enjoy the sport of hunting." This is true. Without artificial production the game might be reduced to extinction if the present rate of slaughter were continued. It is apparent that wild life in Southern Illinois grows less in spite of artificial production. In our efforts to increase game resources are we not thwarted by our eagerness to obtain more revenue by destroying it?

The Shawnee Federal Forestry Unit has introduced into its territory twenty deer about seven of which are thought to survive, twenty beavers which have increased to about seventy, and seventy turkeys about thirty-five of which are thought to be alive and wild. More than 30,000 fish have been planted in the area of 185,000 acres which were controlled by the Unit in 1940.

The following estimates of wild life populations in the Unit as recorded by their numerous official observers give some idea of the struggle which goes on. The figures are estimated populations: Of Quail, 87,900, 6,300 hunters, 1,600 killed; Pheasants, 48, 12 hunters, 2 killed; Woodcock 5, 4 hunters, 0 killed; Mourning Dove 41,000, 8,000 hunters, 2,200 killed; Mink 620, trappers 125, killed 235; Otter 20, trappers 80, killed 5; Muskrat 3,800, trappers 210, killed 1,000; Skunk 8,700; trappers 430, killed 2,200; Raccoon 3,100; hunters 970, killed 500; O'possum 9,600, hunters 2,400 killed 3,100; Red Fox 1,500, hunters 500, killed 270; Gray Fox 6,270, hunters 1,100, killed 700; and ten Wolves and Coyotes were counted in the Jonesboro unit.

It is estimated that there is a permanent waterfowl population of 30 mallards, 30 blue winged teal, 15 green winged teal, 840 wood duck, 80 coots, 50 black duck, 90 lesser scaup, 35 pin tails, 10 canvasback ducks, 15 geese. It is also estimated that 380 mallards, 90 blue winged teal, 15 green winged teal, and 20 coots were killed in the area. The Federal Forestry Unit has no control over the game in its territory.

In addition to planting many thousands of trees in the Shawnee Unit the most important game conserving practice has been the construction of many small lakes, feeding grounds, and shelters to supply food and shelter for the game that already exists. They number 233 and are located as follows: 24% in open fields, 8% in brush, 31% in cultivated areas and 37% in timber. Their average size is less than one fourth acre. Two larger areas of 82 and 33 acres each and three of three each have been constructed. Gravel, moss, etc. have been used in 33 places to improve conditions for aquatic life over an area of 68 acres. Cypress, dogwood, plum, red cedar, and similar growths have been used in five to ten acre shelter patches. Lespedeza, rye, broom grass, etc. have been sown over 400 acres about the ponds and erosion areas. Aquatic plantings such as wild rice, cat tails, smart weed, and sweet flag have been made.

Much of the efforts of state and federal authorities will come to naught if drastic steps are not taken to stop the killing of wild life. Larger areas should be set aside where no hunting or trapping would be permitted. The open season for more kinds of game should be closed for a term of years and then under severe restrictions. Since rabbit fever became a menace to hunters, the number of rabbits has increased perceptibly. It is estimated that there are 238 rabbits per square mile in the Shawnee Unit. It is true that diseases of domestic turkeys may have attacked the wild ones and that severe winters and drought have resulted in the death of many quails; but the greatest menace to wild life increase has been hunters both legitimate and otherwise.

Releasing game in areas where there is lack of protection and where it will mean that the total number grows less each year, is only postponing the time of their practical extermination. Limited reservations which attract large numbers of waterfowl should be surrounded by large areas of cultivated or forest land which could not be especially attractive to water fowl but would give them protection in coming or leaving the water refuges.

A water refuge which is so hemmed in that it can be surrounded by a multitude of hunters in rented shelters every day of the open season appears to be more of a trap than a conservation project.

With due respect to the good efforts of authorities and the many really faithful game wardens, it should be urged that game wardens be selected and continued in office upon their merit only, that they should be assigned to territory where their political friends are absent. Poachers and those who hunt out of season under any pretext should feel safer when the game warden is absent than when he is present.

UNIQUE FLIGHT FORMATION OF BLACKBIRDS

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It is common knowledge that the constant decline of the bird population of North America would result in a critical situation. The alarming reports of the Departments of Conservation and the publications of the Audubon Societies add an atmosphere of realism that is anything but encouraging. Early American literature abounds in narratives of birds filling the air so as to blot out the sun, of birds crowding so thickly on trees as to break the branches, and of birds covering the sky from one horizon to the other. We generally think of such facts as being true only of the past, not as a feature of our time. It would seem to be a rare experience to observe any such phenomenon today.

The purpose of this paper is to report and describe such a flight formation of red-wing blackbirds, now almost a feature of the past, as observed a few months ago.

The formations were observed in the vicinity of Reelfoot Lake, situated in the extreme northwestern corner of Tennessee. While driving south on the Jefferson Davis Highway just outside the limits of Union City on December 21, 1940, at 4:25 P. M., I saw a long, black column of flying birds coming from the east. As the column passed overhead it

was possible to see the individual birds. The formation bent and swayed as it passed through the air. The birds were about one hundred feet above the ground and flew so closely together that the column was only about fifteen feet in width. I watched the passing birds for twenty minutes and yet the end of the column was not in sight. Within the next four miles, two more such formations were seen, stretching from horizon to horizon. The flight direction was toward the west.

Near Troy, Tennessee, sixteen miles south, two more of these long, snake-like, swaying columns of birds passed overhead. These birds were also about one hundred feet above the ground and the columns about fifteen feet in width. Flight direction had shifted, as the birds were now coming from the southeast; the columns extended from one horizon to the other.

On December 30, at 4:20 P. M., while driving north on the Jefferson Davis Highway between Troy and Union City, I sighted six columns of these birds, similar in every respect to those reported on December 21. From the residents of this section I learned that these flights are a common sight each morning after dawn and each evening a short time before sundown. The birds head toward Reelfoot Lake. According to my compass observations, the birds would reach the central portion of the lake. Hunters who know this region verified my observations by stating that the birds settle in the central portion of the lake to feed and rest.

I conclude, therefore, it is still possible to witness one of these rare bird flights which are recorded in the literature of years ago. It is an unusual experience to observe these swaying columns of red-wing blackbirds whose formations stretch from horizon to horizon. A complete record of these flight formations of the Reelfoot Lake region would be extremely valuable. It would be advantageous to know, among many other facts, if such flights encompassed the entire lake, where and how the formation disseminates as well as the methods of growth, the range of the birds, and the daily and seasonal variation of these "regular" blackbird flights.

THE EFFECTS OF CARBON DIOXIDE ON *DAPHNIA*

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Abstract

In all permanent bodies of water there is a group of minute free-swimming organisms known collectively as the plankton. This includes plants (phytoplankton) and animals (zooplankton). Small fish depend entirely upon the plankton for food, as also do the whalebone whales, the largest living animals. Economically the plankton is of vast importance, the fishing industries being directly dependent upon its abundance.

To the biologist this assemblage of organisms presents a number of interesting problems, one of the most puzzling of which is the diurnal vertical migration observed in the group as a whole. These movements are correlated with night and day, so that at noon the majority are found in the deeper water, and at midnight they are nearer the surface. Superficially it appears that the movements are caused directly by light, the organisms perhaps migrating in search for a constant intensity. This explanation may be correct for the phytoplankton, but has not been substantiated for the zooplankton. Laboratory observations on the fresh-water crustacean, *Daphnia*, by von Frisch and Kupelwieser (1913), Clarke (1930, 1932) and others have not disclosed the role of light in the diurnal migrations of this form. Loeb (1904) found that carbon dioxide in water made *Daphnia* strongly photopositive to light from the side, and on this evidence suggested that diurnal variations in the carbon dioxide content of natural waters, brought about by the periodic photosynthetic activity of plants, were responsible for diurnal vertical migrations. This theory has been criticised as not having sufficient experimental proof.

The *Daphnia pulex* used in my experiments were tested for phototropic re-

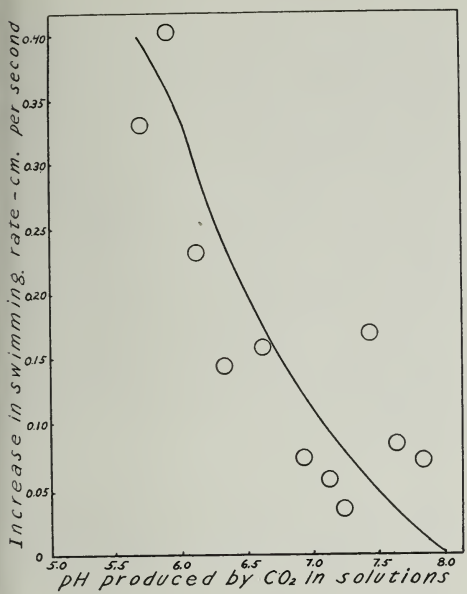

Fig. 1.—Graph showing the effect of carbon dioxide on the phototropic response to light in the horizontal plane.

sponse by placing them in a trough 46 cm. long illuminated through one end by a 100-watt lamp. The bottom was marked off in centimeters so that when animals were dropped into the middle of the trough (zero on the centimeter scale) their movement toward or away from the light could be recorded as plus or minus centimeters, respectively. Filtered Lake Michigan water at about 20°C., was used for the experimental solutions and also in the culture medium in which the animals were kept.

In the first series of experiments, which were for the purpose of finding the normal phototropic response, 2244 *Daphnia* were given one-minute trials in the trough. For the most part these were photopositive to the light source used. When similar trials were extended over a three-hour period, and the positions recorded every six minutes, the average response was much the same. The results are summarized in the tables below. A series of trials similar to those above, but using lake water charged with carbon dioxide in the trough, were next undertaken. Altogether 11 different concentrations of carbon dioxide were used, the solutions ranging from pH 5.7 with 450 parts/million free carbon dioxide to pH 7.8 with 10 parts/million. In each concentration 100 *Daphnia* were tried with the result that most became strongly photopositive, many reaching the end of the trough nearest the light in less than one minute. The time necessary to travel this distance (23 cm.) was then recorded by a stopwatch, and the swimming rate in centimeters per second calculated. Each group of 100 *Daphnia* was also given one-minute control trials in lake water, either one hour before or after the carbon dioxide trials. The difference in swimming rate between control and experimental trials was then considered to be indicative of the effect of carbon dioxide on the phototropic response. This difference was significant in all trials. Figure 1 shows the results.

TABLE I.—PHOTOTROPIC RESPONSE IN LAKE WATER. 1-MINUTE EXPOSURE

Positive		*Negative*	
No. of Animals	Distance	No. of Animals	Distance
2055	25918 cm.	189	1077 cm.
Average:	12.6 cm.	Average:	5.7 cm.

2244 *Daphnia* tested.

TABLE II.—PHOTOTROPIC RESPONSE IN LAKE WATER. 3-HOUR EXPOSURE

Positive	*Recordings*	*Negative*	*Recordings*
429		21	

Average Positions: 18.6 cm. Average Position: 11 cm.

15 *Daphnia* tested.

When trials were extended to 3 hours, as described earlier, it was found that the carbon dioxide effect persisted for about 90 minutes.

In another series of experiments the phototropic response was tested in a 46 cm. long vertical tube illuminated from above. During the trials 4 or 5 *Daphnia* were placed in the tube and their height in the solution recorded by means of a centimeter scale (0 at bottom, 46 cm. at top) at intervals of 1 hour. The animals were tested in this way for 8 hours in lake water, and the next day again tested in a carbon dioxide solution of pH 6.0. In the lake water the *Daphnia* were at an average position of 26.1 cm. for the 8-hour period. In the carbon dioxide solution the same animals averaged 33.2 cm. and the animals did not become adapted as in the horizontal illumination. Table III shows the average hourly positions of the *Daphnia*.

The same kinds of observations were then made with the light source placed to one side of the vertical tube so that it was uniformly illuminated throughout. In

lake water the *Daphnia* then remained at about the same level (average—23.6 cm.) as when the light was from above. In the carbon dioxide solution, however, the situation was reversed, the *Daphnia* being nearer the bottom of the tube (average—8.9 cm.).

The experimental results described are interesting in view of the fact that natural bodies of water usually contain a considerable amount of free carbon dioxide, the amount being greater in the deeper strata of water. Philip (1927) has shown that the carbon dioxide content of a lake studied was subject to appreciable diurnal variation. At night the respiratory activities of plants and animals acted to increase the carbon dioxide content, while during the day carbon dioxide was used up in photosynthesis. If one considers a *Daphnia* to be at equilibrium point with regard to carbon dioxide and light intensity, any increase in carbon dioxide would tend to cause an upward movement toward the brighter surface waters, while a decrease in carbon dioxide would induce sinking to a lower level. This hypothesis, which is similar to that of Loeb, is suggested as a partial explanation. Undoubtedly there are many other factors involved and these may vary in effect in different animals, thereby making any ultimate explanation of diurnal migration a very complex one.

TABLE III.—AVERAGE POSITIONS OF *DAPHNIA* IN A VERTICAL TUBE ILLUMINATED FROM ABOVE

	Height in Tube	
Hours	Lake Water	CO_2 solution of pH 6.0
0	21.9 cm	37.1 cm.
1	26.5	35.5
2	27.7	30.6
3	26.4	30.7
4	33.0	33.0
5	26.9	32.4
6	27.7	31.0
7	23.3	32.3
8	22.0	37.0
	Av. of 36 *Daphnia*	Av. of 35 *Daphnia*
	26.1 cm.	33.2 cm.

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AMPHIBIANS AND REPTILES OF ILLINOIS

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Knowledge of the amphibians and reptiles of Illinois is inadequate for a satisfactory discussion of the status of these groups in the state at the present time. According to available data, about one hundred species and subspecies are known to occur within the boundaries of the state. The number of forms representing the orders of Amphibia and Reptilia are as follows: Caudata 19; Salientia 14; Squamata 46 (lizards 6, snakes 40); Testudinata 21. Some of these must be regarded as doubtful until their presence is verified by carefully determined specimens. There are no endemic forms.

The portions of the state best known herpetologically are the southern and northeastern. The central and northwestern areas are poorly represented by specimens in collections and published reports.

As would be expected from the geographic position of Illinois and the nature of its natural vegetation (chiefly grassland-deciduous forest transition) there is a mingling of prairie and woodland species, the former with affinities toward the west and the latter toward the east and south.

Of special interest are a few western species (of which *Heterodon nasicus* is a notable example) which are regarded as relicts of a population formerly more widely distributed, and associated with a probable postglacial eastward extension of the steppe in North America (Schmidt, 1938, Ecology, 19:396-407).

A cooperative study of the herpetofauna of Illinois is being initiated by the State Natural History Survey Division and the Chicago Academy of Sciences. Anyone interested in giving assistance in the form of specimens or records is invited to correspond with one or the other of these organizations.

INDUCED OVULATION IN *RANA PIPIENS* II.

HENRY C. HILL, JR., AND TRUE W. ROBINSON

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The relation of pituitary injection to ovulation in amphibia has been investigated for several years. Rugh (1937) showed that there is a quantitative relationship between the anterior pituitary hormone and the number of eggs ovulated. He expressed the percentage ovulation in terms of the ratio of the weight of eggs found in body cavity and uteri to the weight of the eggs remaining in the ovary plus the weight of the eggs released. The writers (1940) were able to determine directly the number of eggs ovulated by removing the ovary to frog Ringer's solution before ovulation commenced. When the ovaries were removed as early as 22 minutes after injection with a standard dose of pituitary hormone, some ovulation occurred in the Ringer's solution. As the time between injection of the frog and removal of the ovaries was increased the number of eggs subsequently released also increased. These experiments suggested that if the time during which the ovaries remained in the body were held constant and if the amount of hormone injected were varied, a quantitative relation between the hormone and ovulation would be obtained. That this quantitative relationship exists is shown by the following experiments.

Method.—Frogs received during the winter from Vermont and in the spring from Wisconsin were soaked in cold water and then placed in a refrigerator at 5°C. until used. Host females were selected and weighed in order to obtain some index of their ability to ovulate, since Rugh has found a correlation between body size and potency of the female. Pituitary glands for injection were removed from females, placed in distilled water, and broken up into a fine suspension. The various concentrations of the hormone for each experiment were prepared from such a pituitary suspension. Hypodermic injection was made into the mid-coelomic cavity with a No. 20 needle. After injection the host females were placed in a bell jar in ¼ inch of chlorine-free tap water and kept in the darkroom at 24°C. Six hours after injection the host females were single-pithed down the spinal cord and the ventral surface of the body cavity opened. The ovaries were removed and suspended below the surface of frog Ringer's solution. Ovulation occurred in this solution and by periodic counts until ovulation ceased the rate and total amount of ovulation was determined.

Experiments.—On December 22, 1940 a volume of the pituitary hormone suspension was prepared with a concentration of ten pituitaries per ml. In different volumes, doses of 0.3, 0.9, 1.8, 3.8 pituitaries per female were injected. The maximum amount of ovulation occurred with 0.9 pituitary. An increase of the volume by four times (3.8 pituitaries) did not induce a greater amount of ovulation. (See fig. 1 open circles.)

In subsequent experiments the volume of the injection was kept at one ml and the concentration varied from 0.1 to 8.0 pituitaries per ml of suspension. The total amount of ovulation induced by these concentrations is shown in fig. 1.

On February 2, we obtained a typical ovulation curve with pituitary gland equivalent doses of 0.2, 0.4, 0.6, 0.8, 1.0, and 3.5 pituitaries per ml. (See fig. 1 solid circles.) In the concentration range between 0.4 and 0.8 pituitaries per ml the points fell along a straight line indicating that a direct proportionality existed between the concentration of the hormone and the total number of eggs ovulated. Such a proportionality suggests that the method followed in these experiments may be of use as a biological assay for the amount of pituitary ovulation hormone in various tissues and solutions. On March 22 this relationship was confirmed within this same concentration range. (See fig. 1 inverted triangles.) That the curve had a different slope was probably due to the variability between different shipments of frogs. Ovulation reached a maximum at about 1.0 pituitary. This was shown to hold in the previous experiment and was also borne

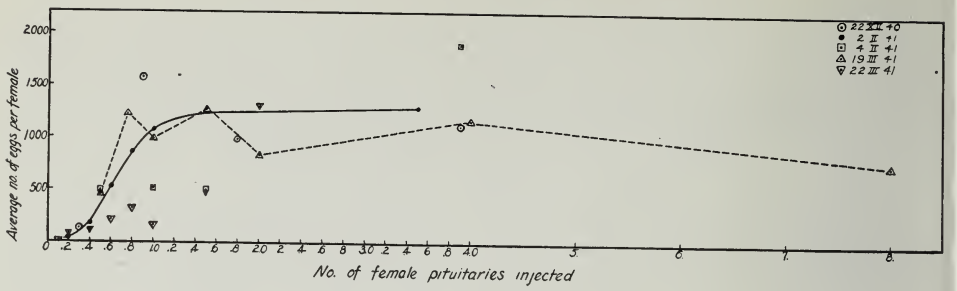

Fig. 1.

out in later ones. It is significant that further increases in the dose even to eight pituitaries induced no greater ovulation. In the lower concentrations, i.e., from 0.1 to 0.4 pituitaries per ml, the points from five experiments all fell close to the typical curve indicating that the response is reproducible in this range.

During March and April frogs showed increased variability in their response to hormone stimulation. Ovulation at this time did not follow closely the curve which was found to be typical in February, the month considered by Rugh best for induced ovulation. Variation of response is caused at least in part by the following factors, more or less difficult to control: The maturity and size of the host female and of the ovary itself (Rugh found larger ovaries more susceptible to hormone stimulation); the amount of available moisture; the storage temperature; the approach of the normal breeding season at which time frogs are less responsive to artificial hormone stimulation. We attempted to control the second and third factors, i.e., the amount of moisture and temperature, by periodically soaking the frogs and by maintaining them at 5°C.

Conclusions.—Using the method of ovulation in Ringer's solution, the effect of pituitary concentrations on ovulation were studied. The results were as follows:

1. In the lower concentrations from 0.1 to 0.4 pituitaries per ml the ovulation response was consistent and increased rapidly with concentration.
2. In the concentration range from 0.4 to 0.8 pituitaries per ml, the total ovulation was directly proportional to the concentration of the hormone. This proportionality suggests that, within this concentration range, a direct biological assay of the pituitary hormone can be made.
3. The maximum amount of ovulation occurred at about 1.0 pituitaries per ml concentration of hormone. Increased concentrations did not induce significantly greater ovulation.

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THE EFFECTS OF FORMALIN UPON DEVELOPMENT IN THE BAR-EYED RACE OF *DROSOPHILA MELANOGASTER*

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Carrollton, Illinois

On June 18, 1936, fresh banana-agar-yeast food to which 5 c.c. of sorghum had been added was made and placed in 8 dram homeopathic vials. Fleishman's yeast was used. On the following day flies from Dr. Zeleny's stock H357B of the bar-eyed race of *Drosophila melanogaster* at the University of Illinois were transferred to it for egg-laying. On June 25 twelve virgins were secured from these vials. They were mated, one pair being placed in each of twelve vials. They were examined to see that they did not vary in somatic characteristics to any great extent from normal for this species. When imagoes emerged from these matings on July 6, 7, and 8, they were removed every 24 hours, those of the same age being put together in a vial.

When the flies were five days old, they were put in one-half pint urinalysis bottles covered with milk bottle caps on which food had been placed 48 hours before. Fifteen pairs were placed in each bottle. One teaspoonful of powdered lamp black was added to the food for the purpose of facilitating egg transfer. A few drops of acetic acid were added also to stimulate egg laying. The flies were placed in an incubator of type 2 made by the Chicago Surgical and Electric Company in a room in which the temperature is kept constant by steam coils and brine coils. The room temperature maintained was 25°C., varying not more than .5°C. at any time. The incubator temperature was 27°C. The flies were kept in the incubator two hours for egg laying. Two more egg laying periods of two hours length were conducted similarly.

Preliminary experiments indicated that the lethal amount of formalin for eggs is in the vicinity of 1.5 c.c. of formalin to 100 c.c. of water, in the food. It was decided to determine the effects of formalin in the food 80%, 60%, 40%, and 20% below the lethal amount for eggs on the somatic characteristics of the adults. During the periods of egg laying food was prepared containing the following proportions of formalin:

1.2 c.c. of formalin to 100 c.c. of water
.9 c.c. of formalin to 100 c.c. of water
.6 c.c. of formalin to 100 c.c. of water
.3 c.c. of formalin to 100 c.c. of water

A control set was also prepared Shell vials of 20 dram capacity were used. One set of 5 vials was used for each concentration of formalin. Twenty eggs were transferred to each vial by means of a dissecting needle, care being taken that the eggs being transferred to one set of vials came from one egg laying period. One hundred eggs were thus transferred to each set of vials having the same amount of formalin. These were kept in the temperature control room at a temperature of 25°C. The temperature did not vary more than a degree at any time.

The adults that emerged were preserved in 85% alcohol. The mean facet counts of the flies raised on food containing these different percentages of formalin and of those raised in the control set are given in table I. The eye facets were counted with a Leitz microscope with a number 4 ocular and a number 3 objective. The facet count of the flies raised in 80% of the lethal amount of formalin for eggs shows a definite drop in the number of eye facets. The number of flies that reached the adult stage, twelve, was too small to give conclusive evidence, however. The larvae, pupae, and adults appeared to be increasingly smaller as the amount of formalin was increased in the food.

Later the experiment was repeated for the purpose of determining the effects of the various amounts of formalin upon the length of the different stages of the life cycle. Observations were made hourly after the eggs were transferred until they had hatched, and also at the time of change from larva to pupa, and from pupa to adult. There seems to be little correlation between the amount of formalin in the food and the length of the egg stage. The lower concentrations of formalin seem to have more effect on the length of the egg stage than the higher concentrations. The controls hatched before

TABLE I.

Percent of lethal amount of formalin used	Amount of formalin used (C. C.'s)	Sex	Number of flies	Mean facet count	Probable error	Standard deviation
80	1.2	Males...	4	60.25	.....	.....
		Females.	8	52.00	.....	.....
60	.9	Males...	28	65.78	.20	8.28
		Females.	40	62.62	.13	7.85
40	.6	Males...	22	71.95	.35	11.70
		Females.	28	60.89	.25	10.59
20	.3	Males...	26	68.50	.26	10.20
		Females.	45	66.00	.11	7.38
Controls	None	Males...	24	70.50	.63	22.36
		Females.	22	65.18	.21	6.90

any of those in food containing formalin.

The mean length of the larval period of flies in the control set was 84.82 hours, while the mean length of the larval period of those in food containing .3 cc. of formalin was 11.64 hours shorter. The mean length of the larva period of those in food containing .6 cc., .9 cc., and 1.2 cc. of formalin had larval periods 40.54 hours, 169.2 hours, and 192.45 hours longer than that of the control set, respectively.

The mean number of hours in the pupal stage was increased 2.47 hours in food containing .6 cc. of formalin, and 1.99 hours in food containing .9 cc. of formalin. Higher amounts of formalin killed the pupae.

The length of ten pupae which developed in each percent of the lethal amount of formalin was measured by means of an ocular micrometer, and the average length was computed. Table II shows the average length of the pupae measured. There was a definite decrease in the length of the pupae with a corresponding increase in the amount of formalin in the food.

TABLE II.

Percent of lethal amount of formalin in food	Amount of formalin in food (C. C.'s)	Average length of pupa cases in millimeters
Controls	*None*	3.42
20	.3	3.05
40	.6	2.68
60	.9	2.39
80	1.2	2.30
100	1.5	2.24

The conclusions drawn from these experiments are summarized as follows:

1. The lethal amount of formalin for eggs of this race of *Drosophila* is in the vicinity of 1.5 cc. to 100 cc. of water in the food.

2. The eye facet number is increased slightly by 20% of the lethal amount of formalin, and definitely decreased by 60% or more of the lethal amount of formalin.

3. The length of the egg stage is increased by 20% and by 40% of the lethal amount of formalin in the food.

4. The lengths of the larval and pupal periods are increased by 40% or more of the lethal amount of formalin in the food on account of retarded development.

5. The size of larvae, pupae, and adults is reduced in direct proportion to the percent of the lethal amount of formalin in the food.

DISTRIBUTION OF UPLAND BIRDS IN ILLINOIS

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According to the life-zone concept of Merriam and others, distribution of birds falls into natural units consisting of great trans-continental belts. Seven of these zones have been described for North America, each bounded on the north and south by isotherms of temperature. With the recognition that different species occurred in the west as compared with the east, certain zones were subdivided at about the 100° meridian on the basis of differences in humidity and rainfall. If one follows this concept the state of Illinois falls mostly in the eastern Carolinian Faunal Area of the Upper Austral Zone. The Transition Zone enters the state on the north and the Lower Austral Zone on the south, but the extent of penetration appears to be a matter of personal judgment. Such a concept is unsatisfactory for analyzing the distribution of the three hundred or so species of birds that occur, as it presupposes a uniform occurrence of a different group of species in each section of the state with their distributional boundaries determined only by temperature.

Doubtlessly temperature does affect the distribution of birds. For instance the chuck-wills-widow, Carolina chickadee, Bewick wren, mockingbird, sycamore warbler, Kentucky warbler, hooded warbler, summer tanager, Bachman's sparrow and others are found more commonly during the breeding season in the southern portions of the state, and the black-capped chickadee, swamp sparrow, bobolink, clay-colored sparrow, and savannah sparrow are mostly confined to the northern portion. Very likely all species have limits of tolerance to extreme temperatures, but these limits vary widely between species. When temperature controls distribution there is little agreement between different species in exact limits of distribution. Likewise correlation between distributional boundaries and isotherms does not prove that temperature is the controlling factor without supporting experimental evidence. For instance, the northward dispersal of the Bewick wren appears limited by competition with the house wren, rather than by the direct influence of any physical environmental factor.

In seeking units of significance for the analysis of distributional phenomena, it is best to utilize the organisms themselves rather than any combination of environmental factors. Unless distribution limits show some harmony and correlation, then distributional units, as such, do not exist in nature. Actually, plants and animals do exhibit fundamental distributional interrelations in the form of biotic communities. These communities give the most substantial basis for interpreting distribution. Exclusive of aquatic areas, two major communities or biomes are represented in Illinois: the forest and the prairie. Their occurrence in the state is shown in fig. 1 which was prepared originally by the Illinois State Natural History Survey[1]. The limits of the constituent avian species are controlled by a complex of environmental conditions, in which moisture, light, and vegetation are especially important.

In addition to these climax communities, there are numerous disturbed areas and subclimax or developmental communities. Most of the prairie has been destroyed for purposes of agriculture or has been greatly modified. Forests have been lumbered or grazing has been permitted so that they no longer represent original conditions. Marshes, lakes, and rivers are subclimax, but if left alone, the smaller lakes and ponds will gradually become choked with vegetation and transformed into communities similar to those now on the upland. Meanwhile they have a varied and characteristic bird fauna of ducks, grebes, coots, rails, gallinules, bitterns, herons, and several species of song birds.

From studies carried out in Trelease Woods at the University of Illinois, a typical list of species occurring in an upland forest in approximate order of their abundance is as follows: indigo bunting, starling, red-eyed vireo, crested flycatch-

[1] Telford, C. J., Bull. Ill. Sta. Nat. Hist. Surv., 16, 1926: I-VI, 1-102.

Fig. 1.—Map showing original distribution of forest (stippled areas) and prairie (clear areas) in Illinois.

er, downy woodpecker, tufted titmouse, wood pewee, red-headed woodpecker, wood thrush, cardinal, yellow-throat, yellow-billed cuckoo, white-breasted nuthatch, barred owl, and Carolina wren. In addition other species occur in irregular numbers. Total abundance of all species averages between two and three birds per acre (Twomey, Hyde, MS).

Extensive tracts of original prairie are difficult to find. Abandoned fields and railroad rights-of-way sometime resemble prairie both in appearance and composition. Representative prairie species that both feed and nest in grassy habitats include marsh hawk, ring-necked pheasant, prairie chicken, upland plover, horned lark, meadowlark, bobolink, dickcissel, and grasshopper sparrow. These are not listed in the order of their abundance. Total abundance of all species may lie between one and one and a half birds per acre[2] which is considerably less than in the forest. In disturbed farmland, pastures, plowed ground, and crops, abundance may drop to one bird per two acres.

Greatest numbers of birds may be found in the forest-edge, or ecotone where forest and open field meet and interdigitate, for here there is a greater variety of habitats, and birds may take advantage of favorable features in more than one. Many of our towns and villages, orchards, cemeteries, shrubby fields, and woodlots are essentially forest-edge habitats. Abundance commonly averages three or more birds per acre and includes, in addition to some species listed for the forest and prairie, the sparrow hawk, bobwhite, mourning-dove, flicker, red-headed woodpecker, kingbird, blue jay, house wren, catbird, brown thrasher, robin, bluebird, English sparrow, bronzed grackle, Baltimore and orchard orioles, goldfinch, and field sparrow.

The presence of extensive forest-edges was characteristic of early Illinois. Birds were probably always numerous as a consequence, and except for the starling, English sparrow, and ring-necked pheasant, were probably of the species above enumerated. The present paper is intended merely to introduce the ecological approach to the study of bird distribution in the state. There are needed many more intensive studies in all habitats to determine the occurrence of species, their actual abundance, fluctuations from year to year, interrelations for territory and food, nesting habits, rates of reproduction and mortality, migration phenomena, and relations to man.

[2] Forbes and Gross, Bull., Ill. Sta. Nat. Hist. Surv., 14, 1922, 187-218.

NOTEWORTHY RECORDS OF OCCURRENCE OF MAMMALS IN CENTRAL ILLINOIS*

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A revived interest, on the part of several zoologists, in the mammals of Illinois prompts me to place on published record the following selected information. This information comprises mainly records of occurrence which better indicate the geographic ranges of several species. The catalogue numbers given refer to those of the writer's private collection.

I am grateful to M. J. Soran and James Francis for assistance in the trapping which yielded some of the information given below, and to E. Raymond Hall, University of California, Berkeley, for suggestions and advice.

Myotis lucifugus lucifugus (Le Conte), Little brown bat.—One was taken on July 21, 1939 flying on the east edge of Brownfield Woods (R. 9 E., T. 20 N., Sec. 34) in Champaign County (No. 250). The species has hitherto not been recorded for this county although Wood (1910) mentions specimens in the State Natural History Survey Collections with data wanting. The identification has been verified by C. C. Sanborn of the Field Museum.

Lasionycteris noctivagans (Le Conte), Silver-haired bat. — One was received from M. J. Soran, who obtained it in a tree in the day time in Piper City (R. 9 E., T. 27 N., Sec. 4). This provides the first record for Ford County (No. 258). The writer shot others at Brownfield Woods in Champaign County on September 18, 1940, and later. Collections of bats were made there at other times during the summer, but September 18 was the first date on which the species was found. Probably these individuals were migrating (Nos. 353, 354, 358, 359).

Pipistrellus subflavus (F. Cuvier), Georgian bat.—Of this species, Wood (1910:596) writes, "If it occurs in the northern part of Illinois it must usually be rare. Either the species is often overlooked or its distribution is very uneven over most of its range." Only one specimen of the Georgian bat was taken in a summer's collecting at Brownfield Woods, Champaign County. This one was shot flying on September 16, 1940. It is the first record for the county and is the northernmost for Illinois, although it has been taken in more northern states (No. 349).

Lasiurus borealis (Müller), Red bat.—The red bat is the species most often seen flying in towns in residential districts where there are a considerable number of trees. It is one of the first to appear in the evening. Often it emerges when there is still enough light for a person to see its color easily. I took one specimen in Piper City, Ford County, flying and feeding at 3 A. M., and many others were seen flying about street lights at this time. This is the most common species in Champaign-Urbana, while in Brownfield Woods, a red oak-maple virgin forest, it is much less abundant (No. 256).

M. J. Soran and I collected fifteen of these bats which were trapped in the fresh oil on a road in Piper City, Ford County (Nos. 338-348). The bats, together with birds of several species, were picked up in midafternoon from the heavily oiled road which was well shaded by trees. Most of the bats were taken within a distance of 500 feet and when washed with gasoline all proved to be this species. Probably the bats mistook the oil for water and were flying to dip into it. The majority of the bats were alive although they were completely covered with oil, which coated also the lining of the mouth. Those exposed to the direct rays of the sun were dead.

Lasiurus cinereus (Beauvois), Hoary bat.—Wood (1910) assumed this species was present in Champaign County, but mentions no specimens. The writer shot one along the edge of Brownfield Woods, Champaign County (No. 335).

Nycticeius humeralis (Rafinesque), Rafinesque's bat.—This species was included in Wood's list although he made no mention of specimens, and Sanborn (1930) records the first one from Cham-

* Contribution from the Zoological Laboratories of the University of Illinois, No. 593.

paign County. The writer collected specimens in Brownfield Woods. There, it was the most abundant species and was found throughout the summer. The presence of large numbers of both adults and young indicates that the species breeds there (Nos. 251-253, 322, 327, 329-331, 333, 335, 357).

Procyon lotor lotor (Linnaeus), RACCOON.—Three skulls of young females were obtained for me by M. H. Goodrich about six miles north of Piper City in Ford County (R. 9 E., T. 27 N., Sec. 2) near a brush pile along a stream. In Ford County suitable cover for raccoons is scarce (Nos. 393-395).

Mustela rixosa allegheniensis(Rhoads), LEAST WEASEL.—The least weasel is not often taken in Illinois although it is probably more generally distributed than records indicate. Fur-trappers frequently tell of taking small or young weasels which they rarely, if ever, save because of the slight fur value. The writer was privileged to examine the skull of a male least weasel taken in a sunken basement window in La Grange, Cook County, Illinois in the autumn of 1939. The skull and the mounted skin are in the possession of Glenn Ulrich of Western Springs, Illinois. The identification was verified by E. Raymond Hall.

Synaptomys cooperi gossii (Coues), GOSS LEMMING MOUSE.—Howell (1927:1) writes: "Synaptomys is not common in collections, but it is by no means certain that it is not more numerous in nature than is generally supposed. Except in a very few places, or in years of unusual abundance, lemming mice have proved exceedingly difficult to obtain in numbers." Wood (1910:559) says "this species seems to be the rarest of the small mammals—or, at least, the one most seldom trapped." He further states that the only specimens he had were two (one without head) found dead near Urbana. He was unable to get additional individuals by trapping in the same area.

The writer collected four specimens of this species in December two miles west of Seymour, Champaign County (R. 7 E., T. 19 N., Sec. 18) within a few hundred feet of the Champaign-Piatt county line. The exact place was in a quadrat that had been trapped over in the previous year by the same method, without indication of the presence of this species. The same general area had been trapped yearly for short periods by ecology classes from the University for ten or more years and no other specimens were ever reported.

The first specimen, a half grown male, was taken on December 10, 1940, on the fifth day of trapping in a quantitative plot. It was dead when found although, it was caught in a live trap. Large numbers of *Microtus ochrogaster* (Wagner), *Peromyscus leucopus noveboracensis* (Fischer), *Cryptotis parva* (Say), *Mus musculus* (Linnaeus), and a few individuals of some other species of small mammals were taken here in the four days preceding. A female was taken on December 15 on the second day of trapping in a second plot, located about 100 feet west of the first. A lactating female was taken on December 20, and an adult male on the following day. The food in the stomachs and intestines of this species was uniformly green-colored, indicating that the animals feed largely on green vegetation even at this time of the year. The green vegetation present was mostly blue grass (*Poa pratensis* L.). The specimens were identified by Donald M. Hatfield of the Chicago Academy of Sciences (Nos. 364, 371, 374, 375).

The trapping which provided the records mentioned above for Ford County has naturally yielded species of commoner occurrence and more general distribution. Those of which the writer has specimens (*), or has handled fresh specimens are as follows:

*Didelphis virginiana Kerr
*Scalopus aquaticus machrinus (Rafinesque)
*Blarina brevicauda (Say)
*Lasionycteris noctivagans (Le Conte)
*Lasiurus borealis (Müller)
*Procyon lotor lotor (Linnaeus)
*Mustela frenata noveboracensis (Emmons)
*Mustela vison mink (Peale and Beauvois)
Mephitis mephitis avia Bangs
*Vulpes fulva (Desmarest)
*Citellus tridecemlineatus tridecemlineatus (Mitchill)
*Citellus franklinii (Sabine)
Sciurus niger rufiventer (Geoffroy)
*Peromyscus maniculatus bairdii (Hoy and Kennicott)
*Peromyscus leucopus noveboracensis (Fischer)

Ondatra zibethica (Linnaeus)
Rattus norvegicus (Erxleben)
*Mus musculus (Linnaeus)
*Sylvilagus floridanus mearnsii (Allen)

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DISTRIBUTION OF ILLINOIS MAMMALS

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At least 53, and possibly 55, species of mammals are know to occur wild in Illinois, and at least two dozen can be found in any community. Thirty-two species are either known to be present in every county (table 1) or are very likely to be found in most counties (table 2), although several bats occur there only during part of a year when migrating. Most mammals, including the furbearers, occur within sight of the limits of every city, even of Chicago.

Table I.—Mammals Known to Occur in Every County

Possum, *Didelphis virginiana* Kerr
Coon, *Procyon lotor* (Linn.)
Long-tailed weasel, *Mustela frenata* Licht.
Mink, *Mustela vison* Schr.
Skunk, *Mephitis mephitis* Schr.
Red fox, *Vulpes fulva* Desm.
Fox squirrel, *Sciurus niger* Linn.
Muskrat, *Ondatra zibethica* Linn.
House rat, *Rattus norvegicus* Erx.
House mouse, *Mus musculus* Linn.
Cottontail rabbit, *Sylvilagus floridanus* Allen
Little brown bat, *Myotis lucifugus* (LeC.)

Table II.—Mammals Known to Occur in All But a Few Scattered Counties

Prairie mole, *Scalopus aquaticus* (Linn.)
Old-field shrew, *Cryptotis parva* (Say)
Mole-shrew, *Blarina brevicauda* (Say)
Little long-eared bat, *Myotis keenii* (Merr.)
Twilight bat, *Nycticeius humeralis* (Raf.)
Gray fox, *Urocyon cinereoargenteus* (Schr.)
Woodchuck or groundhog, *Marmota monax* (Linn.)
Chipmumk, *Tamias striatus* (Linn.)
Gray squirrel, *Sciurus carolinensis* Gmel.
Flying, squirrel, *Glaucomys volans* (Linn.)
Prairie deermouse, *Peromyscus maniculatus* (Wagn.)
Silver-haired bat, *Lasionycteris noctivagans* (LeC.)
Deep-cave bat, *Pipistrellus subflavus* (Cuv.)
Big brown bat, *Eptesicus fuscus* (Beauv.)
Red bat, *Nycteris borealis* (Mull.)
Hoary bat, *Nycteris cinerea* (Beauv.)
Woodland deermouse, *Peromyscus leucopus* (Raf.)
Lemming mouse, *Synaptomys cooperi* Baird.
Mole mouse or pine mouse, *Pitymys pinetorum* (LeC.)
Prairie meadowmouse, *Microtus ochrogaster* (Wagn.)
Jumping mouse or kangaroo mouse, *Zapus hudsonius* (Zimm.)

Generally speaking, our mammals are confined either to woodlands and their associated brushy margins, or to prairies and fields, and are accordingly most abundant where there are extensive habitats suitable to them. Squirrels, for example, are most common in our extensively wooded southern, western and southwestern counties while muskrats are most common in prairie areas (fig. 1, muskrat). Each species, however, is a law unto itself in the matter of distribution because no two select exactly the same type of habitat. This is illustrated by the bag and distribution of squirrels. In the extensively wooded southern counties, squirrel hunters average from ten to twenty times more each year than those in the lightly wooded prairie counties according to hunter's reports (Fig. 1, squirrels).*

Fox squirrels, which prefer thin stands of woods, outnumber gray squirrels in the northern half of Illinois where

TABLE III.—MAMMALS WHICH OCCUR WIDELY ONLY IN COUNTIES IN THE NORTHERN TWO-THIRDS OF ILLINOIS

Coyote, *Canis latrans* Say

Striped ground squirrel, *Citellus tredecimlineatus* (Mitch.)

Franklin's ground squirrel, *Citellus franklinii* (Sabine)

Pennsylvania meadowmouse, *Microtus pennsylvanicus* (Ord)

TABLE IV.—MAMMALS KNOWN TO OCCUR ONLY IN A FEW TIERS OF COUNTIES IN SOUTHERN ILLINOIS

Bachman's shrew, *Sorex longirostris* Bach.

Gray bat, *Myotis grisescens* Howell

Pink bat, *Myotis sodalis* M. & A.

Otter, *Lutra canadensis* Schr.

Bobcat, *Lynx rufus* (Schr.)

Beaver, *Castor canadensis* Kuhl.

Cotton mouse, *Peromyscus gossypinus* (LeC.)

Golden mouse, *Peromyscus nuttalli* (Harl.)

Rice rat, *Oryzomys palustris* (Harl.)

Woodrat, *Neotoma floridana* (Ord)

Swamp rabbit, *Sylvilagus aquaticus* Linn.

Big-eared bat, *Corynorhinus rafinesquii* (Less)

TABLE V.—MAMMALS OF PECULAR AND RESTRICTED DISTRIBUTION

Masked shrew, *Sorex cinereus* Kerr. Chicago region.

Least weasel, *Mustela rixosa* Bangs, so far found only in northeastern counties.

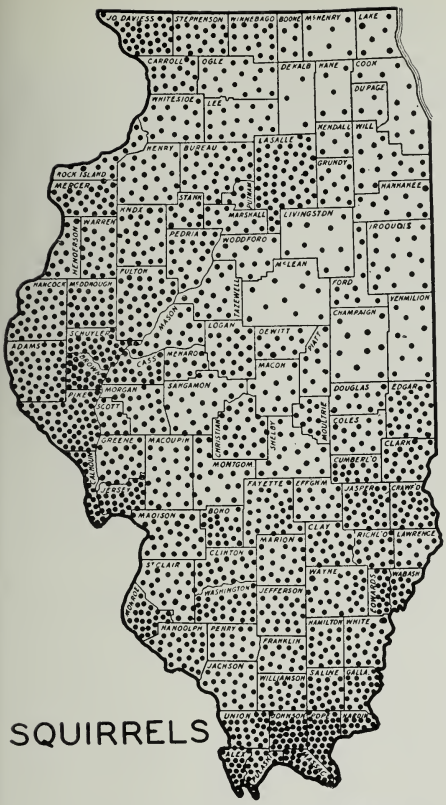
Badger, *Taxidea taxus* Schr., common in counties in the northern third of Illinois.

Pocket gopher, *Geomys illinoensis* K. & S. Present in a few counties in the heart of Illinois, south and east of the Illinois-Kankakee rivers.

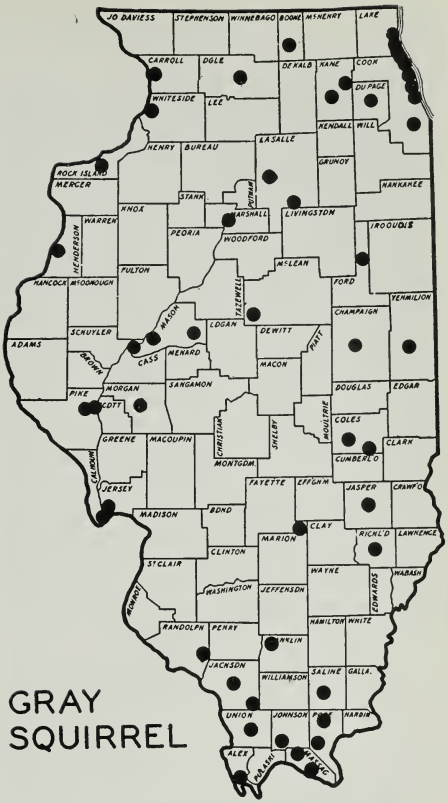
Jack rabbit, *Lepus townsendii* Bach. Present in half a dozen counties in the northwest corner of Illinois.

White-tailed deer, *Odocoileus virginianus* (Bodd.). Chiefly in extreme northern and extreme southern Illinois.

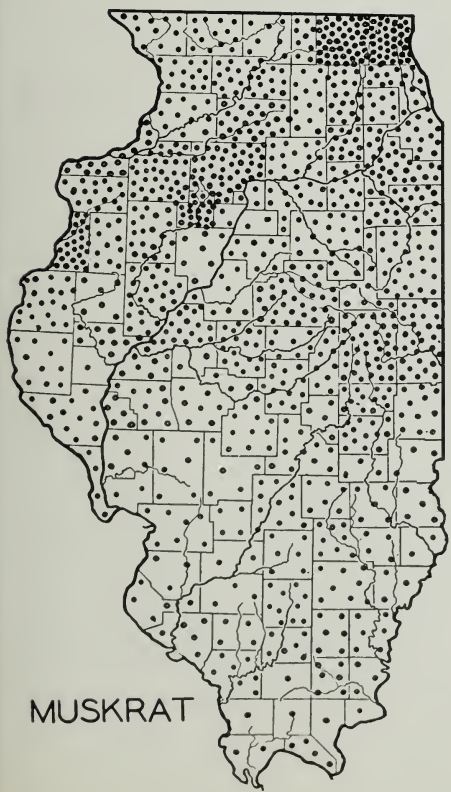
* The writer is indebted to Director Livingston Osborne, Mr. Lewis G. Martin and Mr. J. V. Maloney of the Department of Conservation for the loan of both hunters' and trappers' reports upon which are based the maps and generalizations about distribution of the bag of game mammals and furbearers. From these reports, the average number of animals bagged was calculated and transferred to maps as dots in such a way that counties having the largest bag would also have the greatest concentration of dots.



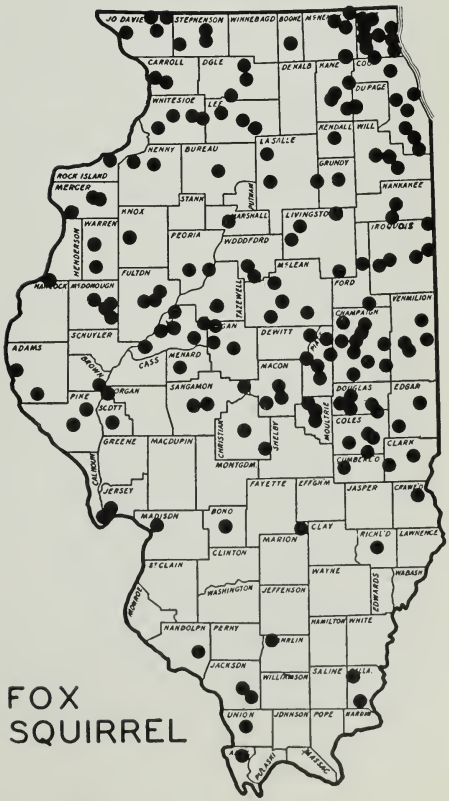
SQUIRRELS



GRAY SQUIRREL



MUSKRAT



FOX SQUIRREL

extensive cutting and heavy pasturing have spoiled the woods for the latter. During the writer's extensive travels on biological surveys of Illinois, for example, he has observed fox squirrels at 157 localities, (fig. 1, fox squirrel), 73 per cent of them in the northern half of the state while observing gray squirrels at 48 localities (fig. 1, gray squirrel) only 54 per cent of which were in the northern half of Illinois.

The bulk of the fox squirrel population lies north of a relatively sharp line of demarcation running east and west, just south of the middle of the state and approximately separating the best black soil area from the poorer yellowish soils. Only 40 per cent of the squirrels observed south of this line were fox squirrels while 60 per cent were gray squirrels which require heavy stands of timber. Conversely only 30 per cent of the squirrels observed north of this line were gray squirrels while 70 per cent were fox squirrels.

Each of the predatory furbearing species also shows similar striking preference for some special area, no two species having exactly the same distribution pattern although all occur in greatest abundance in wooded or brushy counties.

The margins of the ranges of less widely distributed species are very poorly known at present, but it is possible to give a rough idea of the general distribution of each. Future collecting and observation, particularly in marginal counties, will contribute much toward more exact knowledge about the exact pattern.

Star-nosed moles have not been collected in many years and may now be extinct.

BACTERIAL RESPONSE TO GROWTH STIMULANTS*

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This report presents the results of a study on growth rates and fermentative power of bacteria as influenced by carcinogenics and by tissue growth promoting substances.

The effects of the carcinogenics on bacterial growth has been little studied, although Goldstein (1) suggested acceleration of bacterial reproduction as a possible microbiological test for the carcinogenic hydrocarbons. The intermediate life forms as yeast, Cook et al (2), marine hydroids, Hammett and Reimann (3), the planarians and plant rootlets, Owen et al (4) have been utilized and growth was enhanced by the carcinogenics in all instances.

Growth and regeneration stimulation are not specific properties of the carcinogenics. The mechanisms of tissue growth are altered by the carcinogenics. Cook et al (5) noted a reversal of the respiration effect on yeast, from that of stimulation to inhibition in the carcinogenic concentration range most effective for growth promotion. Wright and Anderson (3) found a soluble oxidation product of 1:2:5:6 dibenzanthracene to stimulate growth of Fusarium lini and also to cause a more rapid utilization of glucose. The same carcinogen has been noted as depressing the respiration rate of brain, spleen and liver by Pourbaix (6).

Allantoin is mentioned by Macalister (7) as effective in the promotion of healing with rapid granulation in chronic ulcers. Urea was employed in treating wounds by Symers and Kirk (8). Previously urea had been shown to be a bactericide, Ramsden (9) and Peju and Rajat (10). Various explanations for the apparent growth stimulating effects of urea and allantoin have been offered. Aside from the bacteriostatic action as shown here a most plausible explanation exists in the fact that urea releases free sulphydryl from tissue proteins, Owen (11). Allantoin through its slow release of urea apparently acts similarly as Greenstein (12) has shown guanidine and its derivatives to do.

With reference to larval preparations of the blow fly (Lucilia sericata) Robinson (13) believes the wound healing action to be due to the allantoin content. The urea content of larval preparations is not the sole bacteriostatic agent as removal of this agent by hot alcoholic

* Published under R & P. 6727, Veterans' Administration.

extraction does not eliminate all of the bacteriostatic action of the larval residue.

It seems that simple organisms as bacteria might provide suitable life forms on which to study and possibly standardize growth stimulating agents and the carcinogenics.

Experimental.—For the study a culture of Bacillus coli communior was utilized as this organism displays fermentative powers on the mono and disaccharides. The basic media consisted of three grams of beef extract, five grams of peptone and eight grams of sodium chloride per liter. The sugar medias were made by adding one per cent of the wanted sugar to the above media before final sterilization. Ten tubes of each media comprised each test and the tests were run in duplicate. The concentrations of the substances tested were as follows: urea .5%, allantoin .25%, larval filtrates 1%, ether and alcohol extracts of dessicated larvae—the extractive from two grams placed in thirty c. c. of water, well shaken and filtered. Cysteine hydrochloride, glutathione, indole acetic acid stock solutions were 1:100,000. From .1 to 1 c. c. of the above solutions were added to five c. c. of media. The carcinogenics were added directly to the media in solid form so as to give saturated solutions. Sterilization was done by filtration and by autoclave, each method giving similar results.

The test inoculations consisted of .01 c. c. of a twenty-four hour culture in nutrient broth. To determine the amount of bacteria in the resulting twenty-four hour cultures resort was had to Hopkins tubes. These were centrifuged for thirty minutes at 2030 revolutions per minute.

The results obtained (table A) are given as the quotient of experimental test volume of bacteria over the bacterial volume in the control tubes. Average bacterial volumes from ten tubes for each substance were used in constructing the table.

By the use of the ordinary fermentation tubes the carbohydrate usage appeared not significantly altered by the presence of the carcinogens or growth stimulating agents when these were correlated with final volumes or amounts of bacteria.

The ether and alcohol extracts as well as the residues of dessicated larvae gave positive tests for free sulphydryl by the phosphotungstate procedure.

Discussion.—A bacteriostatic action is displayed by urea, allantoin and by larval preparations. This action is sufficient to overshadow any bacterial growth stimulating properties inherent in these substances. Urea and possibly also allantoin and larval preparations release free sulphydryl on contact with suitable proteins. The carcinogenics do not do this. These growth stimulants and carcinogens do give lowered potentials in

TABLE A.—Showing the effects of growth stimulants and of carcinogenics on bacterial growth rates. Figures represent quotient obtained from test bacterial volume over control bacterial volume. 24 hour cultures and Hopkins tube volumes.

Substance tested in the culture	Media used		
	Nutr. Broth.	Dextr. Broth.	Sacchr. Broth.
Urea	.645	.710	.690
Allantoin	.614	.661	.620
Larva, dessicated, autoclaved	.560	.580	.630
Larva, dessicated, extract	.700	.755	.610
Larva, dessicated, ether ext. of	1.07	.925	.950
Larva, hot alcohol extract of	.632	.685	.730
Cysteine HCl	1.16	1.12	1.00
Glutathione S-S	1.00	.98	1.05
Benzpyrene	.975	1.00	1.23
Dibenzanthracene	.994	1.26	1.32
Triphenyl benzene	.42	.49	.52
Indole acetic acid	.58	.60	.44

solutions as compared to buffer controls Owen (14). The carcinogens 1:2:5:6 dibenzanthracene and benzpyrene display no bactericidal nor bacteriostatic action in nutrient broth but both accelerate bacterial growth rates in media containing saccharose.

Tissue growth and wound healing in the instances of urea, allantoin and larval preparations is most likely a combination of the bacteriostatic and sulphydryl releasing properties of these when placed on open wounds. In contrast the tissue growth promoting properties of the carcinogens cannot be similarly explained. These results would indicate that urea, allantoin and larval preparations might safely be used in dressings of chronic wounds including the malignancies.

Summary

1. Urea, allantoin and larval preparations exhibit a bacteriostatic action in concentrations non-toxic to tissues.

2. The carcinogens do not show a bacteriostatic action and in saccharose containing media, stimulate bacterial growth rates.

3. The mechanism of tissue growth stimulation of urea, allantoin and larval extracts appears to differ chemically from that of the carcinogenics.

Note: Thanks are expressed to Dr. Max Cutler for his kind encouragement and for aid in the preparation of this paper.

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RELATIVE ABUNDANCE OF *CYCLOCEPHALA IMMACULATA* AND *C. BOREALIS* AT URBANA

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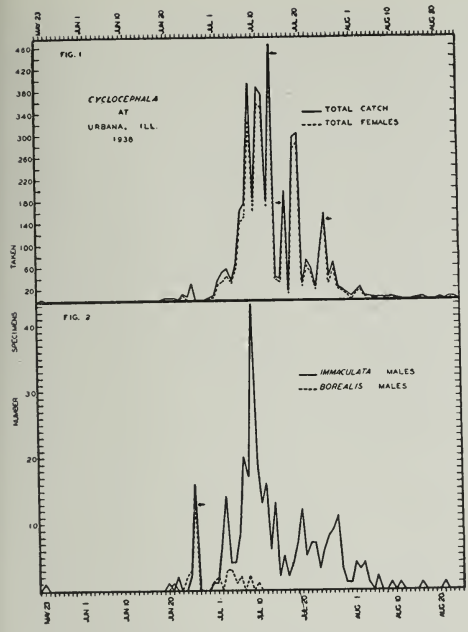
Damage to crops and lawns by "annual white grubs" or "false June beetles" of the genus *Cyclocephala* has been reported at various times from North and South America and the West Indies. Injury is similar to that of ordinary June beetles of the genus *Phyllophaga* and other related Scarabaeids. Valuable plants attacked by the grubs are corn, wheat, oats, barley, sugar cane, sunflowers, strawberries, and the grasses of pastures, lawns and golf courses. As early as 1887 these beetles had been studied under Illinois conditions by Dr. S. A. Forbes.

At Urbana during the summers of 1937 and 1938, while engaged on a light trap project under the direction of Mr. W. P. Flint of the Natural History Survey, I became interested in the genus *Cyclocephala* and saved some of the specimens obtained the first year for a morphological study. It soon became apparent that two species were involved. Consequently in 1938 all specimens taken in the traps were preserved in order that something might be learned of the relative abundance of the two species. This information is desirable since there has been some confusion of the species in the economic literature.



Saylor (1937) in California and Sanderson (1940) in Arkansas have recently published on the taxonomy of the group, with notes on distribution and abundance. The paper by the latter author is of especial interest to us in Illinois because of the species discussed. Hayes (1918), in Kansas, reporting on the life history of *Cyclocephala immaculata* (Oliv.) (misidentified as *C. villosa* Burm.), reviewed the economic literature up to that time. More recently Neiswander (1938) has discussed *villosa* (now called *borealis* Arrow) as it occurs in Ohio. Between 1918 and 1938 scattered notices have appeared on the economic status of the grubs in various regions.

Forbes (1891) stated that our only species of *Cyclocephala* in Illinois is *immaculata*, and this idea seems to have persisted until quite recently. It is true that *immaculata* is the more abundant species in the region of Urbana, but *borealis* is also present in considerable numbers.

During the season of 1938, 4,124 adult *Cyclocephala* were taken in 10 light traps located in the University of Illinois orchards not far from blue grass areas. Since the traps were of the electrocuting type, a few specimens were burned so that they could not be determined even as to sex, but they were counted in the daily totals, fig. 1. Neiswander in his Ohio light trap studies in 1937 found that these insects were attracted to the traps in the ratio of 7 males to 1 female. Yet at Urbana in 1938 the ratio was 10.3 females to 1 male. This difference has no apparent explanation. The curve of seasonal abundance for both species of female *Cyclocephala* is shown in fig. 1.

The two species, *immaculata* and *borealis*, are evidently very closely related and the females, especially specimens from electrocuting light traps, are often difficult to tell apart. So, for the sake of accuracy, our figures on relative abundance are based entirely on the males, fig. 2.

Errors involved in light trap work have been competently discussed by Williams (1939, 1940) and others. While these are freely admitted, I do not believe they seriously affect a study of this type, because these two species are so closely related and each has a one year life cycle. The same factors would apparently affect equally the light trap catch of both. Although a comparison based upon the catch of several years would undoubtedly be better, some idea of the relative abundance of the two species can be obtained from one year's catch. However, it should be pointed out that these beetles have cycles of extreme abundance alternating with years when the population is relatively low as in 1938, and the ratio between *immaculata* and *borealis* probably varies slightly from year to year.

Of the male *Cyclocephala* taken in 10 light traps at Urbana in 1938 *immaculata* outnumbered *borealis* in the ratio of 9.3 to 1. It is interesting to note that the first male *immaculata* was taken on May 23, and the last on August 21, while all the *borealis* appeared between June 21 and July 10.

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DISTRIBUTION OF ILLINOIS INSECTS

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The insect fauna of Illinois, estimated at approximately 20,000 species, brings out interesting generalities regarding the place of Illinois in the continental distribution of species, the types of abode of insects within the State, seasonal succession of species and their horizontal stratification.

Within the State itself insect distribution is influenced primarily by differences in vegetation. This is a result of the close dependence upon specific host plants of a large number of insect species. Many species occur principally in open prairie; these same ones often frequent weed patches around cultivated land. Another large set of species inhabits the forest, many of them actually feeding on various kinds of trees. Still a third large set prefers the forest edge region which occurs between the prairie and forest areas wherever these two are side by side, and which contains a wide variety of trees and shrubs, each harboring different insect species.

A wide variety of insects range over the entire State in whichever general category they frequent. This includes many in which Illinois is in the heart of the species range, as in the case of the housefly and periodical cicada.

Other species are more restricted and occupy small areas which are of a more special type. A few areas of unusual interest are (1) White Pines Forest State Park and Starved Rock State Park, unique in Illinois in having insects restricted to white pine; (2) glacial lakes, swales and marshes in extreme northeastern Illinois, including many northern species which intrude into the Illinois fauna only in this area, fig. 1; (3) tamarack bogs in this same section with insect species restricted to this small area by either host preference or other limiting factors; (4) cypress swamps found in extreme southern Illinois, containing many insects intruding from the south, fig. 1, including species of crickets, plant bugs, and others which feed only upon cypress; and (5) the most diverse faunal feature of extreme southern Illinois, the Ozarkian Uplift. This has a wide variety of rock, hill, and meadow

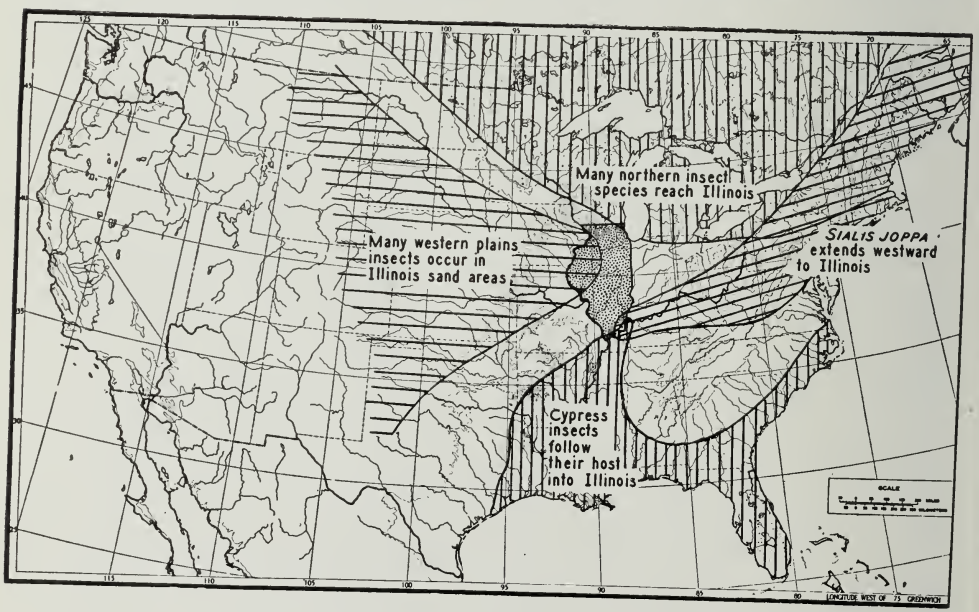

FIG. 1.

situations, in addition to unique streams in which are many species of insects found nowhere else in the State. Many of these species are eastern or typically Ozarkian in general distribution. An example is the alder fly, *Sialis joppa*, whose known range is shown in fig. 1. In various parts of Illinois occur extensive tracts of blow sand and dunes; most notable are those at Zion, along the shores of Lake Michigan, others near St. Anne, Savanna, Rock Island, Amboy and Havana. These areas sustain a typical sand flora and fauna and account for the presence in this State of many unique insect species. Most of these have a range centering in the western prairie, fig. 1.

The place of Illinois in the continental range of its insect species is varied. In the case of a large proportion of its species Illinois is in the central part of the range, which may be wide or limited. In many other cases the species intrude into the State from ranges which center to the east, south, west or north. Examples are given in fig. 1. So many intrusive species of many diverse groups have been taken in the State that it is apparent that Illinois has an axial position in regard to many faunal regions of North America.

Seasonal distribution of the insects within the State is tremendously complicated. Since Illinois has severe winters and hot summers, there is a very marked seasonal succession of species throughout the year. Hordes of insects are active during spring, summer, and fall. Others including springtails, stoneflies, and a few other aquatic insects, are active also during the winter months. Due to the difference in climate between northern and southern Illinois, this seasonal succession is very different in the two ends of the State.

Equally complex is the distribution of Illinois insects among the various strata. Certain forms are adapted to spend their entire life cycle in the soil, others in the herbs, others in the shrubs and trees. Most insects, however, may be found in more than one stratum, frequently spending the larval stage in one, the pupal stage in another, and the adult stage in several.

MODIFICATION OF A TROPISM IN *LUMBRICUS TERRESTRIS*

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The present experiment deals with an attempt to produce modification of response in the night crawler. It is well established that earthworms react negatively to intense illumination and to galvanic shock. An earthworm introduced into a T maze of which one side is lighted and one side darkened might be expected to enter the darker compartment. If, however, the worm received a shock while in the dark and the shock were repeated as the worm progressed further or remained quiescent it might eventually leave the dark. This was found to be the case.

The subjects were large sized *Lumbricus terrestris* (10-12 inches). The maze was a T shaped box, each arm of which was 15 inches long. The bottom was covered with thick blotting paper which was soaked with water before each trial run. The source of light was a 40 watt frosted bulb with a white reflector. The lamp was suspended 3 inches from the floor. A partition extended down to within three-eighths inches of the floor between the illuminated arm and the darkened arm. The starting arm was open. Each worm was kept in a separate container, was taken out, washed, placed in the starting arm, given a light shock and the time recorded. The shocks were administered by electrodes on the floor.

A worm was shocked further only if it advanced nine inches into the darkened chamber. Trial runs were made at the same time daily. Records were kept of elapsed time, number of shocks, and directions of movement both initially and

throughout the trip. Near the conclusion of the experiments the maze was reversed in an attempt to determine whether there had been learning or merely lateral muscle training.

The earthworms learned to avoid the dark and seek the light. This was indicated by the decrease in time required for the trial, decrease in number of shocks, an increase in the number of initial turns to the light, and finally by the behaviour in the maze. There were 17 worms used in the experiments at the start but some were killed by overshocking, and other accidents, before the trials were finished.

After 15 trips on successive days the average trip time was 2.5 minutes as compared with 5.2 minutes the first day. There are 98 chances out of a hundred that this difference was due to learning. The average number of shocks required to force the worms to the light decreased from 9 to 4 during 15 days. There are 99 chances out of a hundred that this is not fortuitous. On the first day no worm made an initial turn to the light without the compulsion of shock and the percentage of initial turns to the light for the first 6 days was 5.6 while from 15-19 days inclusive the initial turns to light averaged 44.3%.

After the fifth day the worms were more likely to leave the dark upon receiving a shock but as they drew near to the light they turned and re-entered the dark where another shock was administered. This process was repeated until the worm went under the light. On the seventh day oscillating movements sometimes referred to as "selection by random movement" were noticed. Light and dark were equally repellent.

The individual record of worm No. 10 seems to substantiate the value of our criteria. The first trip required 20 minutes and 15 shocks while the 15th trip required 1 minute and 1 shock. For the first five trips the initial choice was dark and for the following 18 trips the initial choice of dark occurred only 4 times.

To avoid the criticism that the worms learned a direction or followed a slime trail the experimental set was reversed on the 20th day. The record of number 10 after the reversal showed an increased trip time. Trips had been consuming from one-half to one minute but the first day after reversal 3.5 minutes were needed and 8 shocks. On the 21st day the same trip was made in one-half minute and no shock was given. The initial turn to the light was voluntary.

Conclusions

1. Negative phototropism of Lumbricus is subject to modification and possible elimination under experimental conditions.
2. This would indicate that tropisms may be partially acquired rather than entirely inherent.

A CORRELATION BETWEEN THE RATE OF HEART BEAT AND THE STATE OF CERTAIN CHROMATOPHORES IN THE SHRIMP, *PALAEMONETES*

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An Abstract

The first suggestion of a relationship between the state of the chromatophores and the rate of heart beat was made by Gamble and Keeble (1900). These investigators found that the nocturnal phase (pigment concentrated) of the shrimp, *Hippolyte varians*, was accompanied by a higher rate of heart beat than the day phase (pigment dispersed). It is now well established that the migration of the pigment in certain chromatophores of crustaceans, which results in color changes, is controlled by hormones produced in the eye-stalks.

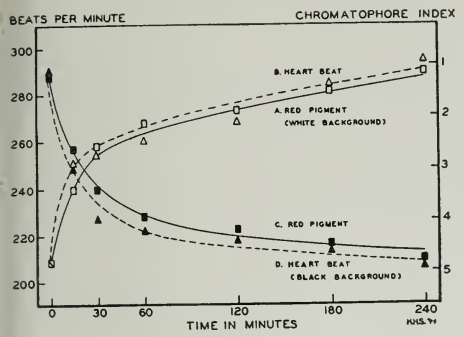

Fig. 1.—The rate of red pigment migration and the changes in the rate of heart beat in Palaemonetes when placed on black and white backgrounds.

Recently, Welsh (1937) presented evidence to suggest that the rate of heart beat, at least in the crayfish, is also controlled by substances present in the eye-stalk. However, in later experiments (1939) he pointed out that the acceleration of the heart rate was due to acetylcholine, present in the eye-stalk and other nervous tissue, rather than to the eye-stalk hormones which controlled the pigment migration. Brown (1940) demonstrated that the source of the chromatophore-activating substance was actually the sinus gland, located within the eye-stalks.

The purpose of the experiments reported here was to ascertain whether the sinus gland has an effect on the heart rate, by determining whether or not there is a correlation between the rate of heart beat and the state of certain chromatophores in the marine shrimp, *Palaemonetes vulgaris*. The animals were placed in small dishes containing sea water, which was kept at a constant temperature (20° ± .5°C.), and observed with a dissecting microscope. The rate of heart beat was determined with the aid of a stop watch. The state of the chromatophores was measured by the Chromatophore Index method, which consisted of assigning values ranging from 1 (pigment fully concentrated within the chromatophore) to 5 (pigment fully dispersed) (Brown and Scudamore, 1940). Only the red chromatophores showed a definite correlation with the rate of heart beat. This is an interesting observation since only the concentration of the red pigment seems to be entirely controlled by the sinus gland (Brown, 1940).

Experimental Results.—To correlate the rate of heart beat and the state of the red chromatophores, observations were made with the animals placed on different colored backgrounds. In one group of experiments, animals were "black-adapted" by placing them in black dishes for four hours; these "black-adapted" animals were then transferred to white dishes and observed periodically. The results of experiments on ten animals are illustrated in fig. 1. In the "black-adapted" animals, at the beginning of the experiment, the red pigment was fully dispersed (average Index 4.8) and the rate of heart beat low (209 beats per minute). On the white background, the pigment (curve A) gradually concentrated into the center of the chromatophore (average Index 1.1), while the rate of heart beat (curve B) increased to 295 beats per minute. The slopes of the two curves for the rates of change are similar.

In another group of experiments, ten animals that had been "white-adapted" for four hours were transferred to black dishes and observed periodically. In this case the red pigment (curve C, fig. 1), which was concentrated at the beginning of the experiment (average Index 1.2), gradually dispersed to average Index 4.8; and the heart rate (curve D), which was high at first (291 beats per minute), gradually decreased to 206 beats per minute over a period of four hours. Here again parallel curves were found for the average rates of change.

The rate of pigment migration in each case agrees with that reported by Brown (1935). In explaining these color changes, it has been suggested, that on a white background the red-pigment-concentrating hormone is liberated into the blood stream; this causes a concentration of the red pigment, and, as shown here, an increase in the rate of heart beat. On a black background this hormone is absent from the blood stream; the red pigment then disperses, and is accompanied by a decrease in the rate of heart beat.

The relationship of the sinus gland to these parallel changes was further established by the results of extirpation and injection experiments. Following bilateral extirpation of the eye-stalks of eight "white-adapted" animals (average Index 1.2; heart rate, 289 beats per min-

TABLE I.—ANALYSIS OF THE RELATIONSHIP BETWEEN THE CHROMATOPHORE INDEX AND THE RATE OF HEART BEAT

Red Chromatophore index	Rate of Heart Beat			
	Average beats per minute	Standard deviation	Standard error	Number of observations
1	293	±14.72	±2.36	40
2	265	±17.35	±2.97	35
3	249	±16.65	±2.60	42
4	225	±13.25	±1.84	53
5	203	±12.07	±1.78	47

ute), the red pigment dispersed to average Index 5.0 and the heart rate decreased to 201 beats per minute. Graphs of the rate of change in each case closely followed curves C and D (fig. 1.) This low rate of heart beat and dispersion of red pigment in blinded animals persisted for several days.

In one series of experiments .02 cc. of a sinus gland extract (of a concentration corresponding to 20 sinus glands to 1 cc. of filtered sea water) was injected into each of five blinded animals. In the blinded animals the average Index was 4.8 and heart rate was 206 beats per minute; fifteen minutes after injection, the red pigment had concentrated to average Index 1.0 and the heart rate increased to 292 beats per minute. This was followed by a dispersion of the pigment and a decrease in the heart rate similar to that indicated in curves C and D (fig. 1). An alcohol extract of *Carcinus* sinus glands showed a similar concentration of pigment and at the same time an acceleration of heart rate. Sea water extracts of muscle tissue had no appreciable effect on the heart rate or chromatophores. Acetylcholine and a sea water extract of nervous tissue accelerated the heart rate but did not affect the chromatophores.

The results of an analysis of the rate of heart beat associated with each chromatophore index in the four to seven readings made on each of the 33 animals reported here are shown in table I.

The average rate of heart beat is high when the pigment is concentrated; low when the pigment is dispersed. The coefficient of correlation of these results is —0.91, which indicates a definite negative correlation. Thus as the red pigment concentrates, the heart rate increases; and as the pigment disperses, the heart rate decreases. The main significance of such statistical analysis is to emphasize the parallel changes.

SUMMARY

A definite correlation was shown to exist between the rate of heart beat and the state of dispersion of the red chromatophores in *Palaemonetes*. The evidence suggests that this is influenced by the red-pigment-concentrating hormone of the sinus gland. Thus, in addition to causing a concentration of red pigment when present in the blood stream, the hormone also appears to cause an acceleration of the rate of heart beat.

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OBSERVATIONS FROM A STUDY OF THE COMPARATIVE ANATOMY OF THE EXTRAHEPATIC BILIARY TRACT

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Abstract

For the student in zoology who is looking forward to a medical career, a study of the comparative anatomy of the biliary tract should prove an aid to the fuller comprehension of anomalies he will later observe in the dissection laboratory, in the operating room and at the autopsy table.

Historical Survey.—A brief survey of some of the contributions to the knowledge of the comparative anatomy of the extrahepatic biliary tract, although very incomplete, shows that interest in the extrahepatic biliary tract has been evidenced since earliest times. Some of these contributions are considered in the full length manuscript.

Summary of Observations. — In the studies which are summarized in this paper, observations were made as completely as the condition of the specimen or the amount of the material allowed. Almost all of the specimens were obtained through the courtesy of the staff of the Field Museum of Natural History and the many kindnesses of the staff are gratefully acknowledged. A full report which includes most of these dissections has been published by the Field Museum of Natural History (1).

Altogether, 111 animals were studied. These represented twelve orders and fifty-two species. The data obtained are summarized under seven distinct but related topics.

1. **The presence or absence of the gall bladder.**—In fifty-two species of Mammalia, a gall bladder was absent in only eight—the whale (*Balaenoptera physalus*), the zebra (*Equus burchelli*), the horse (*Equus caballus*), the dassie (*Procavia sp.*), the white-tailed deer (*Odocoileus virginianus*), the brown rat (*Rattus norvegicus*), the pocket-gopher (*Geomys bursarius*) and the rice-rat (*Oryzomys meridensis*).

In Hyracoidea, Perissodactyla and Cetacea the gall bladder was absent. In Rodentia, as in Artiodactyla, there was variability among the species. In Marsupialia, Primates, Edentata, Carnivora, Insectivora and Chiroptera, a gall bladder was present in all specimens studied. In the one specimen of Sirenia (*Trichechus latirostris*), there was a gall bladder. The variability among the Rodentia was of particular interest.

2. **The character of the wall of the gall bladder** was determined only by its opacity and by palpation of the structure. It showed much variability. In Chiroptera and in Insectivora the wall was thin; it was firm in Marsupialia and Artiodactyla; it was strong and thick in Carnivora and the Primates. In Rodentia it was variable, e.g., thin in the guinea-pig (*Cavia porcellus*) and the house mouse (*Mus musculus*), but firm and thick in the African porcupine (*Hystrix cristata*).

3. **The relationship of the gall bladder** to the liver varied between and within orders. In Marsupialia, with the exception of the opossum (*didelphis mesamericana*) it was loosely adherent to the liver. In the flying phalanger (*Petaurus norfolcensis*), the viscus was loosely lodged in its fossa; in the Tasmanian devil (*Sarcophilus harrisii*) the gall bladder was loosely attached to the liver by a peritoneal fold for two-thirds of its length. A short peritoneal fold which connected the gall bladder to the liver was seen in the Chiroptera studied. The loose attachment to the liver was observed in Primates. In the Carnivora, particularly deep fossae were seen in the binturong (*Arctitis binturong*) and the dog (*Canis familiaris*). In the black bear (*Ursus americanus*), the gall bladder was loosely attached to the liver. In Rodentia, the variability was again marked.

4. **The duodenal papilla** showed variability, not only as to its presence or abscence, but also as to its size. It was

TABLE I.—RELATION OF PANCREATIC AND BILE DUCTS*

Species	*Type A*	*Type B*	*Type C*	*Gall-bladder*
Tree-kangaroo *(Dendrolagus matschiei)*	+			+
Wallaby *(Macropus sp.)*	+			+
Flying phalanger (*Petaurus norfolcensis*)	+			+
Tasmanian devil *(Sarcophilus harrissii)*	+			+
Mexican opossum (*Didelphis mesamericana*)	+			+
Orangutan (*Pongo pygmaeus*)	+			+
Chimpanzee *(Pan satyrus)*	+			+
Macaque *(Macaca mulatta)*	+			+
Marmoset *(Tamarin ursulus)*	+			+
Red Uakari *(Cacajao rubicundus)*	+			+
Dog *(Canis familiaris)*	+			+
Cat *(Felis domestica)*	+			+
Little panda *(Ailurus fulgens)*				+
Binturong *(Arctitis binturong)*			+	+
Armadillo *(Dasypus novemcinctus)*	+		+	+
Sheep *(Ovis aries)*				+
Cow *(Bos taurus)*			+	+
Pig *(Sus scrofa domestica)*		+		+
Florida Manatee *(Trichechus latirostris)*		+		+
Dassie *(Procavia sp.)*		+		+
Zebra *(Equus burchelli)*	+			0
Horse *(Equus caballus)*	+			0
African porcupine *(Hystrix cristata)*	+			0
Guinea pig *(Cavia porcellus)*		+		+
Striped ground squirrel *(Citellus tridecemlineatus)*		+		+
House mouse *(Mus musculus)*		+		+
Brown rat *(Rattus norvegicus)*			+	+
Rabbit *(Oryctolagus cuniculus)*			+	0
Rice-rat *(Oryzomys meridensis)*		+		+
			+	0

* Key: Type A—Ducts course together to duodenal wall; Type B—Ducts enter duodenum separately at variable distance from each other; Type C—Pancreatic duct joins bile duct at distance from opening of the latter into duodenum.

prominent in the black bear (*Ursus americanus*) in which a gall bladder was present. It was equally prominent in the zebra (*Equus burchelli*) in which there was no gall bladder. It was not present in the binturong (*Arctitis binturong*) which had a gall bladder, nor in the dassie (*Procavia sp.*) in which there was no gall bladder. The duodenal papilla varied within an order as to its presence and size, e.g., in the bear (*Ursus americanus*) and the dog (*Canis familiaris*); it was absent in the binturong (*Arctitis binturong*).

5. The distance of the opening of the bile duct from the pylorus was markedly variable. In two species of Rodentia, the African porcupine (*Hystrix cristata*) and the guinea pig (*Cavia porcellus*) it was nearest to the pylorus. Both of these species possessed gall bladders. In two species of Artiodactyla in which the gall bladder was present, a marked difference was observed. In the domestic cow (*Bos taurus*) the opening was 62 cm. caudad to the pylorus, but in the pig (*Sus scrofa domestica*) it was 3.4 cm. Naturally the question arises as to the comparative length of the small intestine in these species. The ratio of the length of the small intestine of the former to that of the latter is approximately 3 to 1.

6. The relationship of the common bile duct or the common hepatic duct (when there is no gall bladder) with the pancreatic duct was of great interest to Mann and his co-workers (2) and they made studies of this relationship in laboratory and common domestic animals. These relationships in the specimens examined in the series here reported are summarized in table 1.

It was observed that the type of relationship did not correspond with the presence or absence of the gall bladder. Again there was particular variability among the Rodentia, e.g., the guinea pig (*Cavia porcellus*) was in type B; the brown rat (*Rattus norvegicus*) was in Type C. It should be noted that in the seven species in which the ducts entered the duodenum separately at variable distances from each other (type B), a gall bladder was present in each species.

7. Other observations. Hepato-cystic ducts which drain from the liver into the side of the gall bladder or into the cystic duct along its course have been observed in various vertebrates. In this series they were particularly observed in the cow (*Bos taurus*). They were injected with gelatin and dissected carefully in order definitely to establish their existence. The surgical importance of hepatocystic ducts, when present in man, lends added significance to these structures when encountered in zoological studies.

One of the interesting observations which were made in this study concerned the dassie or hyrax. The author has previously reviewed several reports of investigations on the viscera of hyrax and reported his findings (3).

REFERENCES

1. Thomson, S. C. 1940. Studies of the anatomy of the extrahepatic biliary tract in mammalia. Zool. Ser., Field Mus. Nat Hist., vol. 22. pp. 415-430.
2. Mann, F. C., J. P. Foster and S. D. Brimhall. 1920. The relation of the common bile duct to the pancreatic duct in common domestic and laboratory animals. J. Lab. and Clin. Med., vol. 5, pp. 203-206.
3. Thomson, S. C. 1938. The extrahepatic biliary tract of the hyrax. Anat. Rec., vol. 72, pp. 445-449.

STATE OF ILLINOIS
DWIGHT H. GREEN, Governor

TRANSACTIONS

OF THE

ILLINOIS STATE ACADEMY OF SCIENCE

VOLUME 34 MARCH, 1942 NUMBER 3

PRELIMINARY PROGRAM

Thirty-fifth Annual Meeting

Friday and Saturday, May 8 and 9, 1942
UNIVERSITY OF ILLINOIS, URBANA

Published by the Academy
Affiliated With the Illinois State Museum Division
Department of Registration and Education
Centennial Building, Springfield, Illinois.

PUBLISHED QUARTERLY

Entered as second-class matter December 6, 1930, at the post office at Springfield, Illinois, under the Act of August 24, 1912.

ANNOUNCEMENTS

Authors submitting manuscripts for consideration by the publications committee of the 1942 **Transactions** must leave them with Section Chairmen on or before May 8th. These scripts must be in final form. They must be typed **(double spaced)** in dark ribbon, and should not exceed 1200 words in length (including tables and not more than one illustration) unless special arrangements are made. (This amount makes 2 printed pages, and holds down for author the cost of reprints and extra pages.) Beneath title should appear author's name and in a separate line his school and /or town. At the end of article should appear **address to which proof is to be sent next November.** Inasmuch as the Academy does not have funds for preparing illustrations, all drawings, charts, and special formulae must be submitted by the author in India ink, and all photographs in gloss print (no photostats can be used), with each figure mounted on a separate sheet with title typed below. Any author whose paper is published must be a member of the Senior Academy ($1.00 annual dues) and must pay an editorial fee of $1.00 to help defray expenses of publication.

Authors are asked to send, if possible, brief **abstracts** of their articles, immediately to **J. S. Ayars, Publicity Director, 131 Natural Resources Bldg., Urbana, Ill.** If Section Chairmen already have these abstracts, please forward at once to Mr. Ayars.

Requests for research grants from the **A.A.A.S.** are received each year up to March 31st and recipients announced at the May meeting of the Academy. Chairman for the current year is William C. Rose, Dept. of Chemistry, University of Illinois. Chairman for the ensuing year will be announced in the June issue of the **Transactions.**

The Academy announces that a **Collegiate Section** is being formed for undergraduate college and university students. Response from college groups has been so immediate and enthusiastic that a program of 36 papers is being given at its first meeting See pp. 255-6.

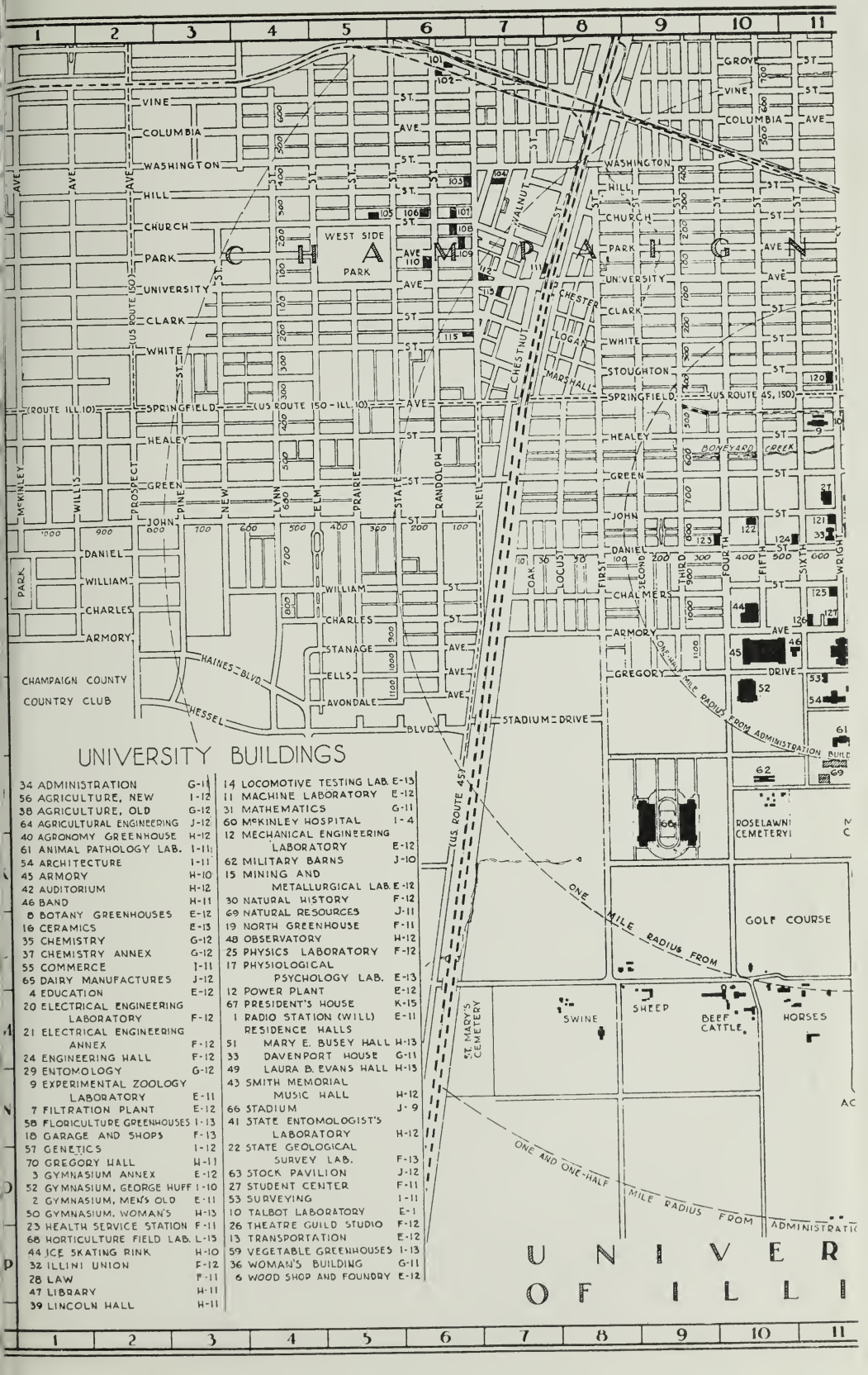
State Physics Teachers Association, affiliated with the Academy, will meet in 119 Physics Bldg., Green St., University of Illinois Campus, on Friday morning, May 8th, from 10 to 12 o'clock, and at a special table at the general Academy luncheon.

Illinois Conference of Family Relations will meet from 11 a. m. to noon and from 4:30 to 5:00 p. m. (business meeting) Friday, May 8. Place will be announced at time of registration. The Conference will join with the Social Science Section of the Academy for luncheon and afternoon sessions.

A lecture-demonstration by Dr. Phillips Thomas, Westinghouse Electric and Mfg. Co., will be given at Lincoln Hall Theatre Thursday eve., May 7, under sponsorship of Student Branch A. I. E. E. (Admission by ticket.)

Sigma Delta Epsilon, an organization of graduate women in science, will sponsor a breakfast at 7:30 Saturday morning for all women, including high school students, who are interested in science. Place and price will be announced at time of registration.

Saturday morning trips will consist this year of visits to important museums, and Junior Academy Exhibits, and inspection of research facilities of the University of Illinois and of the scientific surveys on the campus. The cyclotron, betatron, etc. are included on the itinerary, as well as the Physical Science Museum. Details will be published in the Final Program. Members of Senior Academy, the Collegiate Section, the Junior Academy, and their guests are urged to indicate their choice at the time of registratiton on Friday morning, May 8th.



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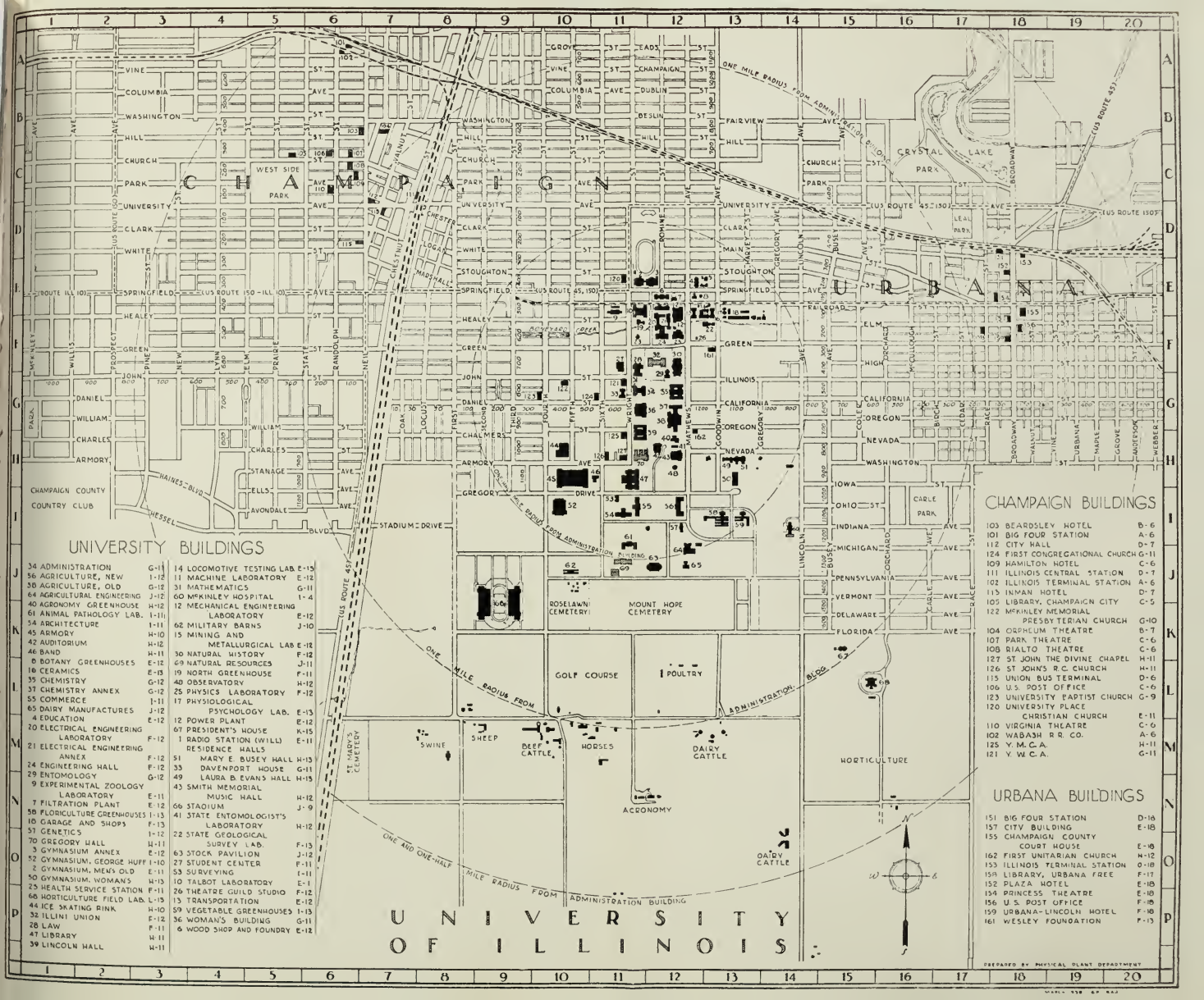
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GENERAL PROGRAM

ALL ADDRESSES AND SECTION MEETINGS OPEN TO THE PUBLIC

University of Illinois Campus, Urbana

May 7-8-9, 1942

THURSDAY, MAY 7

6:00 *p. m. Council Meeting and Dinner.* Colonial Room Illini Union Bldg., Green St.

FRIDAY, MAY 8

8:00 *a. m. Registration* by all members and guests. Securing of Final Programs, tickets for annual banquet, registration for Saturday Visits. Lincoln Hall Lobby.

8:45 *a. m. Preliminary business meeting* of the Academy for all members. Appointment of nominations, resolutions and auditing committees. Lincoln Hall Theatre

9:30 *a. m. General Session.* Lincoln Hall Theatre.

Welcome by Arthur Cutts Willard, President of the University of Illinois. Academy Presidential Address and Motion Picture in Color: "Conservation Research Program of the Illinois Natural History Survey," Theodore H. Frison, Chief of the Natural History Survey, Urbana.

Illustrated Lecture: "The Design, Construction and Operation of a Cyclotron." P. Gerald Kruger, Professor of Physics, University of Illinois, Urbana.

12:00 *Luncheon,* Third Floor, Illini Union Bldg., Green St. 65 cents.

Mail reservations to George E. Ekblaw, Geological Survey, Urbana *by May* 1.

1:00-4:30 *Junior Academy* Science Club Exhibits on display for judging, and open to public inspection. Lower Gym, Woman's Bldg., Wright St.

1:30-4:30 *Section meetings*: Senior, Collegiate, and Junior. University of Illinois classrooms and lecture rooms. All papers, to be considered for publication, must be given to Section Chairmen by the end of this session. See Announcements page for specifications.

5:00-5:30 *Business Meeting for all members Senior Academy.* Will be streamlined. Please come. Lincoln Hall Theatre.

6:00 *p. m. Annual Banquet* for Senior Academy, Collegiate Section, and guests. Illini Union Bldg. $1.00 Informal. Announcements of A.A.A.S. research awards. *Mail reservatitons to George E. Ekblaw, Geological Survey, Urbana, Ill., by May 1st.* Call for tickets by 10:30 on Friday, May 8th, at registration desk.

8:15 *p. m. Annual Lecture* for everyone attending Academy sessions, and for the general public. "A Naturalist in the South Seas," illustrated, by Karl P. Schmidt, Chief Curator, Dept. of Zoology, Field Museum of Natural History, Chicago. University of Illinois Auditorium. Special section will be reserved for those attending Academy banquets.

SATURDAY, MAY 9

8:45 *a. m. Meeting of the Council* for 1942-43. Dr. Frison's office, 135 Natural Resources Bldg., South Campus.

9:30 a. m. Annual Trips. Important museums and the Junior Academy exhibits will be visited, and trips conducted to inspect research facilities of the University and of the scientific surveys located on the campus. Details will be given in the Final Program.

SECTION MEETINGS

FRIDAY, MAY 8, 1942
1:30-4:30

AGRICULTURE, C. H. Oathout, Chairman, Macomb, Ill.
103 New Agriculture Bldg.

Election of Chairman for 1942-43.

1. Germination studies of brome grass.
   R. F. Fuelleman, Univ. of Illinois, Urbana.

1a. What are we doing with castor beans? W. L. Burlison and R. F. Fuelleman, Univ. of Illinois, Urbana.

2. Relative photosynthetic capacity of stalks, leaf sheaths, and leaf blades in maize as measured by the contribution each makes to the development of the grain.
   Geo. H. Dungan, Univ. of Illinois, Urbana.

3. Using slope of land as a basis for farm planning.
   Burdette Graham, Prairie City Community H. S.

4. The chemical composition of farm crops as affected by soil type and treatment.
   H. J. Snider, Univ. of Illinois, Urbana.

5. The practical side of the nitrogen cycle.
   E. R. Spencer, McKendree College, Lebanon.

6. Results of experiments in improvement of pastures for dairy cattle.
   W. B. Nevens, Univ. of Illinois, Urbana.

7. War production and soil conservation in Illinois.
   Oren L. Whalin, Univ. of Illinois, Urbana.

8. The out-of-school education for rural youth.
   D. E. Lindstrom, Univ. of Illinois, Urbana.

9. The use of genetics in solving the variety problem for peach growers.
   M. J. Dorsey, Univ. of Illinois, Urbana.

10. Cross-breeding in swine.
    E. Roberts, Univ. of Illinois, Urbana.

Leave manuscripts with Chairman by end of meeting

ANTHROPOLOGY, Donald E. Wray, Chairman, 604 Caroline St., Peoria
120 Architecture Bldg.

Election of Chairman for 1942-43.

1. Indian trail markers.
   Floyd L. Barloga, Peoria.

2. Report on the Archaeology of Pere Marquette State Park.
   George M. Link, Grafton.

3. Additional Clear Lake Village materials.
   Mrs. E. Schoenbeck, Peoria.

4. Tree ring dating in the middle west.
   John W. Griffin, Daytona Beach, Fla.

5. Analysis of archaeological sites.
   Donald E. Wray, Peoria.

6. Archaeological horizons in southern Illinois.
   Moreau Maxwell & John Bennett, Univ. of Chicago.

7. Panel discussion: Middle Mississippian Culture.

Turn papers in to Chairman before leaving.

BOTANY, J. Fisher Stanfield, Chairman, Chicago Teachers College.
217 Noyes Chemistry Lab.

Election of Chairman for 1942-43.

1. Leaves in ontogeny and phylogeny.
   Sister Mary Ellen O'Hanlon, Rosary College, River Forest.
2. A penicillium "disease" of ink.
   Robert A. Conover & Neil E. Stevens, Univ. of Ill.
3. The white-bracted Hymenopappus still grows in Illinois.
   Leo R. Tehon, Natural History Survey, Urbana.
4. Nitrogen content of oat chloroplasts.
   Arthur W. Galston, University of Illinois.
5. Plant sanctuaria.
   Jens Jensen, Ellison Bay, Wisconsin.
6. Rate of transpiration in two oat varieties grown under varying soil moisture levels.
   Glenn Ray Noggle, University of Illinois.
7. Notes on the distribution of some rarely reported species of Oedogonium.
   Max E. Britton, Northwestern University, Evanston.
8. Preliminary studies on the riboflavin (vitamin B2) content of plant materials.
   Stanley A. Watson, University of Illinois.
9. A study of the phytoplankton of Crab Orchard Lake.
   Walter B. Welch, Carbondale.
10. A checklist of the vascular plants in the University of Illinois woodlands.
    G. Neville Jones, University of Illinois.
11. Naphthalene acetic acid and the growth and composition of cereal grasses.
    R. E. Stephenson, University of Illinois.
12. A revision of the Illinois species of Rumex.
    Sidney Glassman, University of Illinois.
13. Island groves in Illinois prairies.
    A. G. Vestal, University of Illinois.
14. The Illinois species of Solidago.
    Dorothy Croker, University of Illinois.
15. Trees and shrubs of Champaign County, Illinois.
    Albert Feldman, University of Illinois.
16. Some growth responses of Soja and Vinca to vitamins.
    J. Stanfield Fisher, Chicago Teachers College.
17. New interpretations of Sphenophyllostachys based on a petrified specimen from an Iowa coal ball, A. T. Cross, Univ. of Cincinnati.

Turn manuscripts in before leaving.

CHEMISTRY, N. D. Cheronis, Chairman, 5556 Ardmore Ave., Chicago.
112 Chemistry Annex

Election of Chairman for 1942-43.

1. The role of the chemistry teacher in national defense.
   C. E. Ronneberg, Herzl Junior College, Chicago.
2. What the colleges are doing for national defense.
   H. W. Gould, Northern Ill. State Tchrs. College, DeKalb.
3. Review of 1940-41 movies useful in the teaching of physical science.
   L. V. Peterson, Supervisor Vis. Aids, Univ. of Ill.
4. Review of 1940-41 chemistry texts for use in the teaching of chemistry at the high school level.
   S. A. Chester, Bloomington H. S.
5. Review of 1940-41 texts for teaching of chemistry in first two years of college.
   M. H. McLain, Wilson Junior College, Chicago.

Chemistry (continued)

6. Suitable curricula for courses in high school chemistry.
   Sister M. Joan, College of St. Francis, Joliet.
7. Introducing new acid base terminology.
   C. W. Bennett, Western Ill. State Tchrs. College, Macomb.
8. Demonstration of unstable anionic complex formation by the method of electrometric titration with specific reference to indium salt solutions.
   T. Moeller, University of Illinois.
9. New sources of mineral elements in animal nutrition.
   W. P. Elmslie, Quincy.
10. Semi-micro methods in the teaching of chemistry: a review.
    N. D. Cheronis & P. G. Arvan, Wright Junior College, Chicago.

Turn manuscripts in before leaving

GEOGRAPHY, Joseph Van Riper, Chairman, Southern Ill. Normal U., Carbondale.

161 Noyes Chemistry Lab.

Election of Chairman for 1942-43.

1. The Black Sea and its borderlands. (Illustrated)
   W. O. Blanchard, University of Illinois.
2. Regional reality from the concept of space-time.
   Clarence L. Brown.
3. The colonial question.
   Flemin Cox, Southern Ill. Normal Univ., Carbondale.
4. Soils and rural population trends in Decatur County, Georgia.
   Alfred Booth, Univ. of Illinois.
5. The Murngin: an example of human geography.
   Edna M. Gueffroy, Bloomington.
6. Clay Products manufacture in the lower Wabash Valley.
   Alden Cutshall, Univ. of Illinois.
7. The uses and production of tung oil.
   Geo. C. DeLong.
8. The saxicultural landscape of the Sudbury area. (By title.)
   Thomas C. Barton, Southern Ill. Normal Univ., Carbondale.
9. The relations of geographic factors to some diseases.
   Geo. R. Wells, Senior High School, Decatur.

Give manuscripts to Chairman before leaving

GEOLOGY, A. H. Sutton, Chairman, University of Illinois, Urbana.

202 Entomology Bldg.

Election of Chairman for 1942-43.

1. Bituminous matter in Warsaw geodes.
   Percival Robertson, Principia College, Elsah.
2. Chester index ostracodes.
   C. L. Cooper, Illinois Geol. Survey, Urbana.
3. Devonian stromatoporoids.
   Allen F. Agnew, Univ. of Illinois, Urbana.
4. The morphology and distribution of Tasmanites ("Sporangites"); problematic fossils of the Devonian-Mississippian.
   J. M. Schopf, Illinois Geol. Survey, Urbana.
5. Niagara cherts from northern Illinois and southeastern Indiana.
   H. A. Lowenstam, Illinois State Museum, Springfield.
6. Rhythms in Upper Pennsylvanian cyclothems.
   J. M. Weller, Illinois Geological Survey, Urbana.

Geology (contiuned)

7. The "Trenton" near Morris, Illinois.
   C. L. Bieber, North Central College, Naperville.
8. Subsurface cross-sections near type Chester localities in western Illinois.
   F. E. Tippie, Illinois Geological Survey, Urbana.
9. Use of the Glen Dean limestone as a structural key horizon in the Illinois basin.
   G. V. Cohee, Illinois Geological Survey, Urbana.
10. Upper Pennsylvanian fossiliferous zones of Vermilion and Edgar counties.
    George M. Wilson, University of Illinois, Urbana.
11. Thickness of the glacial drift in DuPage County.
    A. C. Mason, Illinois Geological Survey, Urbana.
12. Incompetent sediments in the Illinois basin.
    W. H. Easton, Illinois Geological Survey, Urbana.
13. Future importance of strip mining in Illinois.
    G. H. Cady, Illinois Geological Survey, Urbana.
14. Small spores from Illinois No. 5 coal.
    A. L. Brokaw, Illinois Geological Survey, Urbana
15. Shape variation of some Lake Superior beach pebbles.
    R. M. Grogan, Illinois Geological Survey, Urbana.
16. Thermal analysis of pyritic clays.
    R. A. Rowland, Illinois Geological Survey, Urbana.
17. Redwall limestone of north-central Arizona.
    R. C. Gutschick, University of Illinois, Urbana.
18. The Pleistocene geology of Garrison quadrangle, North Dakota.
    Edward Simpson, University of Illinois, Urbana.

Turn papers in to Chairman by end of meeting.

PHYSICS, F. L. VerWiebe, Chairman, Univ. of Chicago, (On leave from E. Ill. St. Tchrs. Coll., Charleston.)

119 Physics Bldg.

Election of Chairman for 1942-43.

1. The inverted pendulum.
   C. N. Wall, North Central College, Naperville.
2. Meteorology. A new method of long range weather forecasting.
   W. E. Ewert, Chicago.
3. Normal daily temperatures for Aurora by comparison with Chicago.
   Clarence R. Smith, Aurora College, Aurora.
4. A demonstration power supply.
   O. L. Railsback, Eastern Ill. State Tchrs Coll., Charleston.
5. Color vision.
   V. Kibort, University of Chicago.
6. A demonstration radio set.
   A. F. Inglis, University of Chicago.
7. An outline of a physics course related to the C. A. A. program.
   Theodore Phillips, Wright Junior College, Chicago.
8. Falling bodies and the cause of gravity.
   W. C. Ewert, Chicago.
9. Why not express the horsepower in foot-poundals?
   C. E. Ronneberg, Herzl Junior College, Chicago.
10. X-Ray diffraction studies on physiological changes in bone.
    C. I. Reed and B. P. Reed, Univ. of Ill. Coll. of Medicine, Chicago.
11. The betatron, by D. W. Kerst, Univ. of Illinois.

Leave manuscripts with Chairman before going.

PSYCHOLOGY and EDUCATION, J. M. Hughes, Chairman, Northwestern University, Evanston, Ill.

319 Gregory Hall

Election of Chairman for 1942-43.

1. The problem of college student morale during war.
   Frances W. Hibler, Ill. State Normal Univ., Normal.
2. The war between human nature factions.
   Coleman R. Griffith, Univ. of Illinois.
3. Mental hygiene effects of war upon children.
   Paul A. Witty, Northwestern Univ., Evanston.
4. Financing public education in Illinois with specific reference to the war period.
   C. A. DeYoung, Ill. State Normal Univ., Normal.
5. Hand writing as a factor in credit rating.
   William R. Laughlin, Loyola Univ., Chicago.
6. What can the elementary school do to prepare for winning the peace?
   Edwin H. Reeder, Univ. of Illinois.

Hand manuscripts in before leaving.

SOCIAL SCIENCE, C. W. Schroeder, Chairman, Bradley Polytechnic Institute, Peoria, Ill.

1. Luncheon meeting. University Y.M.C.A., Wright St.
   Paper by Florian Znaniecki; The Social Scientist in Time of Crisis.
2. Afternoon meeting.

214 New Agriculture Bldg.

Election of Chairman for 1942-43.

Federal regulation of business enterprise. V. Dake Jolley, Wheaton College.
The village population of Illinois. Samuel C. Ratcliffe, Illinois Wesleyan.
Chicago and the down state. William B. Philip, Bradley College.

(Thirty-minute discussion of above led by Albert Lepawsky, Univ. of Chicago.)

Symposium on "The Fate of the Family."

Ernest R. Mowrer, Northwestern.
B. F. Timmons, Univ. of Illinois.
Clarence W. Schroeder, Bradley College.
Ruth Shonle Cavan, Rockford.
Ernest W. Burgess, Univ. of Chicago.

(Discussion of points brought out in above symposium, by Evelyn Millis Duvall, Assoc. for Family Living, Chicago.)

Hand manuscripts to Chairman by end of meeting.

ZOOLOGY, Orlando Park, Chairman, Northwestern University, Evanston, Ill.

"Interrelations of Insects with Other Organisms."

Section A. Symposium

228 Natural History Bldg.

Election of Chairman for 1942-43.

1. Insects in relation to plants.
   a. Vectors of pathogenic organisms. L. R. Tehon, Ill. Nat. Hist. Survey.
   b. Other relations with plants. Harry Hoogstraal, Univ. of Ill.
2. Insects in relation with other insects.
   a. Entomophagy of solitary forms. W. V. Balduf, Univ. of Ill.
   b. Social life. A. E. Emerson, Univ. of Chicago.
3. Insect relations with animals other than insects.
   a. Parasites and vectors of pathogens, C. L. Metcalf, Univ. of Ill.
   b. Insects as food of vertebrates. H. H. Ross. Ill. Nat. Hist. Survey.

Section B. General

229 Natural History Bldg.

F. A. Brown, Jr., Chairman, Northwestern University

1. Zoological courses in the early days of the University of Illinois.
   H. J. Van Cleave, Univ. of Illinois.
2. Stimulating an interest in the history of natural science.
   S. C. Thomson, Chicago.
3. Wildlife conservation as a part of soil conservation.
   H. E. Gearhart, Edwardsville.
4. Work and endeavors of the Hoogstraal Mexican biological expeditions.
   Harry Hoogstraal, Univ. of Illinois.
5. Pre-caval anomalies of the cat.
   J. M. Sanders, Chicago.
6. Comparative pharmacology of myogenic and neurogenic hearts.
   C. L. Prosser, Univ. of Illinois.
7. Induced ovulation in Rana Pipiens, III.
   T. W. Robinson, Univ. of Illinois.
8. Pseudo-cleavage of the frog's egg.
   H. C. Hill, Jr. and T. W. Robinson, Univ. of Illinois.
9. Effect of testosterone propionate on territoriality in flocks of ring doves.
   Mary A. Bennett, Macomb.
10. Color discrimination in canaries.
    H. H. Shoemaker, Univ. of Illinois.
11. Distribution pattern of pheasants and quails in Illinois.
    C. O. Mohr and R. E. Yeatter, Ill. Nat. Hist. Survey.
12. A southern Illinois heronry.
    Collan Hill, Southern Ill. Normal Univ., Carbondale.
13. A preliminary report on a herpetological survey of Illinois.
    H. K. Gloyd, Chicago Acad. of Sciences.
14. Bass and bluegill feeding experiments.
    D. H. Thompson and Bruno von Limbach, Ill. Nat. Hist. Survey.
15. Results of a creel census at Chautauqua Lake.
    D. F. Hansen, Illinois Natural History Survey.
16. Cyclocephala Abrupta in Illinois.
    G. T. Riegel, Illinois Natural History Survey.
17. Distribution of two Illinoian Orthoptera.
    W. V. Balduf, University of Illinois.
18. Locality records of some Hydracarina from Illinois.
    C. C. Hoff, Quincy College.
19. Distribution of Spiders in the Indiana dunes associes.
    D. C. Lowrie, Chicago Academy of Sciences.

Hand manuscripts to Chairman before leaving.

COLLEGIATE SECTION

Papers and demonstrations by undergraduate college and university students. For information about this Section, write Harold R. Wanless, Dept. of Geology, University of Illinois, Urbana, Ill.

FRIDAY, MAY 8, 1942

Morning Session coincides with Senior Academy program on page 248.

1:00 p. m. Preliminary General Meeting. 100 Gregory Hall.
1:30 p. m. Presentation of papers in Sections A, B, and C.
4:30 p. m. Business meeting for delegates of science clubs or groups in the colleges and universities of Illinois. 100 Gregory Hall.

Banquet and evening program same as Senior Academy. See p. 248.

SATURDAY, MAY 9

Collegiate Section A.

BOTANY, ZOOLOGY, ENTOMOLOGY, PSYCHOLOGY and HYGIENE

100 Gregory Hall

1. Flowering plants collected in Wauconda county.
   Mary Jane Poranski, Northwestern University, Evanston.
2. Some extremes in the algae.
   Marian E. Westgate, Rosary College, River Forest.
3. The taxonomic significance of leaf epidermal hairs.
   Patricia Borgstrom, Rosary College, River Forest.
4. The herpetological distribution of a southern Mexican mountain and valley transect.
   Fred Shannon, Univ. of Illinois, Urbana.
5. Tundra bird studies.
   Oscar Hawkesly, Principia College, Elsah.
6. A preliminary ecological study of Slim Island.
   H. Merritt Paulson, Principia College, Elsah.
7. Collecting insects in winter.
   Chas. L. Remington, Principia College, Elsah.
8. The distribution of butterflies in a southern Mexican mountain-valley transect.
   Ralph Haag, University of Illinois, Urbana.
9. The ethnography of the Ibo, Nigeria, West Africa, with special reference to problems of primitive education.
   Julius Okala, Northwestern Univ., Evanston.
10. Scientific observations on flavors.
    Lee Froetscher, Elmhurst College, Elmhurst.
11. Identification of visual patterns protracted in time.
    Henry Pachowicz, Ill. Inst. of Technology, Chicago.
12. Students as school nurses.
    Thelma Newgard, Elmhurst College, Elmhurst.
13. The Effect of the descaling of winter buds on their growth in east central Illinois.
    John Voigt, E. Ill. State Tchrs. Coll., Charleston.

Collegiate Section B.

PHYSIOLOGY, ANATOMY and BACTERIOLOGY

213 Gregory Hall

1. Studies of cardiac frequency in the embryonic chick.
   Orlando A. Ponzio, Loyola Univ., Chicago.
2. Adventures with a new tissue illuminator.
   Alex Lutzow, Elmhurst College.
3. The microscopic anatomy of lebistes reticulatus.
   Warren Clohisy, Loyola Univ., Chicago.
4. Bleaching and mounting pig skeletons.
   Arthur Borucki, Loyola Univ., Chicago.
5. Effects of anterior pituitary extracts on certain organs in the white rat.
   PART I. Lorraine Pawlan; PART II, Dorothy Rodwell, Rockford College, Rockford.
6. The influence of forced exercise upon the guinea pig.
   Howard Raiser, Illinois Inst. of Technology, Chicago.
7. A study of placental extracts.
   C. M. Fordis, University of Illinois, Urbana.
8. Chlorophyll in treatment of athlete's foot.
   Frances Foster, University of Illinois, Urbana.
9. Zapatera spoilage of olives.
   V. Del Giudice, University of Illinois, Urbana.
10. Methods of preserving cultures.
    A. R. English, University of Illinois, Urbana.
11. Anatomy of His-Tawara.
    Larry Sanford, Wheaton College, Wheaton.

Collegiate Section C

PHYSICAL SCIENCE (Chemistry and Geology)

223 Gregory Hall

1. Electric well logs.
   James Pearson, University of Illinois, Urbana.
2. Chemical analysis of petroleum found in geodes.
   Albert Gruenewald, Kohn Kneeland, and Dan Lynch, Principia College, Elsah.
3. Ecological evidences of fluctuations in Alaskan glaciers.
   George P. Brown, University of Illinois, Urbana.
4. Fauna and probable correlation of the Arrowhead member of the Monte Cristo limestone; Nevada.
   Betty Teetor, University of Illinois, Urbana.
5. Structural control of ore deposition in the Arkansas cinnabar area.
   P. H. Dodd, Northwestern University, Evanston.
6. Festooned facies of the casper sandstone.
   Mary Tullgren, Northwestern University, Evanston.
7. A study of hydrogen ion concentration.
   Edith Godar, Rosary College, River Forest.
8. Radio activity with reference to the periodic table.
   Florence Schmisseur, College of St. Francis, Joliet.
9. Certain pH Determinations.
   Edna May Lewis, Rosary College, River Forest.
10. and 11. Papers in chemistry from Wright Junior College, Chicago.
12. Building a geology museum.
    Joseph Hoare, Augustana College, Rock Island.

JUNIOR ACADEMY MEETINGS.

Louis A. Astell, Local Arrangements Chairman, University H. S., Urbana

MAY 8-9,1942

UNIVERSITY OF ILLINOIS CAMPUS, URBANA

FRIDAY, MAY 8

8:00 a. m. Registration, Lower (East) Parlors, Woman's Bldg., Wright Street.

Setting up of exhibits. Lower Gym, Woman's Bldg.

Junior Academy members not otherwise occupied are cordially invited to attend the general morning session of the Academy in Lincoln Hall Theatre beginning at 9:30. There will be two main talks, one on Natural History in Illinois and the other on the Cyclotron.

12:00 Luncheon. University Place Christian Church, Wright Street. 45 cents.
1:00-4:30 Inspection and judging of exhibits. Lower Gym, Woman's Bldg.
2:00 General Session. 112 Gregory Hall.

Remarks by President Jack Frenzen, J. Sterling Morton High School, Cicero.
Presentation of Junior Academy officers.
Roll call of clubs and presentation of membership certificates.
Report of A.A.A.S. honorary members Mary Catherine Rowley, Canton H. S., and Bill Hahn, East Rockford H. S.
Illustrated talk, "Geologic history of the Grand Canyon," by Kenneth Gutschick, J. Sterling Morton H. S., Cicero.

Kenneth has a first hand knowledge of the Grand Canyon. He spends his summers there with his brother who is an instructor in Geology at University of Illinois.

Movie: "High speed motion pictures." Allen R. Moore, J. Sterling Morton H. S., Cicero.

Annual Afternoon Lecture: "Phosphorescence and Fluorescence" L. W. Phillips, Physics Dept., University of Illinois

6:00 Annual Banquet. University Place Christian Church. 60 cents.

8:15 Annual Lecture for Junior, Collegiate, and Senior Academies.
A Naturalist in the South Seas (illustrated), by Karl P. Schmidt, Chief Curator, Dept. of Zoology, Field Museum of Natural History, Chicago. University of Illinois Auditorium. Special section will be reserved for those attending Academy banquets.
Junior Academy Awards will be announced immediately after lecture.

SATURDAY, MAY 9

9:30 Visits to museums and Junior Academy exhibits, and inspection of research facilities of the University of Illinois and the scientific surveys located on the campus.
Details will be given in the Final Program.

N. B. Exhibits may remain in place for general public inspection Saturday, but must be removed by 6:00 p. m. Saturday.

GENERAL INFORMATION

Headquarters

Messages sent to be received in Urbana prior to registration may be addressed in care of George E. Ekblaw, 216 Natural Resources Bldg., Urbana. On Friday and Saturday, May 8 and 9, they should be addressed in care of Mr. Ekblaw, Illini Union Bldg.

Headquarters for the Academy Friday forenoon will be in Lincoln Hall Foyer. Junior Academy headquarters will be in Lower (East) Parlors, Woman's Bldg.

Long distance telephone messages on *Friday* may be placed through Champaign 7-4044, except Junior Academy registrants may be reached through Champaign 7-2115.

Room Accommodations

Those who desire hotel accommodations should communicate directly with the hotels, which are as follows:

URBANA: *Urbana-Lincoln.* With bath, single $2.75 and $3.30; double $4.00 and $4.50; twin beds $5.50. With lavatory and toilet, single $1.90; double $3.00. Without bath, single $1.65; double $2.75. Suites and large rooms with bath, for 3 or more, $2.00 to $2.75 per person.

Plaza. With bath, single $2.00 and $2.25; double $3.00 and $3.25. Without bath, single $1.25 and $1.50; double $2.00 and $2.25.

CHAMPAIGN: *Inman.* With bath, single $2.50, $2.75, and $3.30; double $3.50, $5.00, and $5.50; twin beds $5.00, $5.50, and $6.60. With lavatory and toilet, single $2.00; double $3.00. Without bath, single $1.65 and $2.00; double $3.00; twin beds $3.30. Connecting rooms with bath, $5.00 for 2 persons, $6.00 for 3 or 4 persons. Rooms with 2 double beds, with bath, $6.75 for 3, $8.00 for 4 persons; without bath, $4.00 for 4 persons.

Tilden-Hall. With bath, single $2.20 and $2.75; double $3.85 and $4.40. Without bath, single $1.65; double $2.75.

Hamilton. With bath, single $2.00 and $2.50; double $3.00, $3.50 and $4.00. Without bath, single $1.50; double $2.50 and $3.00.

Accommodations for those who prefer not to stay at hotels will be provided in private rooming-houses in the University district, at rates ranging from 50 cents to $1.00 per person per night. These accommodations will be arranged in cooperation with the University Housing Division. Reservations should be made by May 1, on the enclosed form.

Meals

Luncheon and banquet tickets for the Academy and for the Junior Section will be obtained at their respective registration desks Friday forenoon May 8. However, reservations should be made on the enclosed form by May 1.

Inspection Trips

Inspection trips Saturday forenoon will start from the Illini Union Bldg. promptly at 9:30. Those who plan to go on these trips should so indicate at time of registration.

THE LIBRARY OF THE
JUN 13 1942
UNIVERSITY OF ILLINOIS

STATE OF ILLINOIS
Dwight H. Green, Governor

Transactions

of the

ILLINOIS STATE ACADEMY OF SCIENCE

Volume 34 June, 1942 Number 4

Reports Concerning the Thirty-fifth Annual Meeting, Urbana, Illinois May, 1942

Memoirs

PRINTED BY THE ILLINOIS STATE ACADEMY OF SCIENCE
Affiliated with the
ILLINOIS STATE MUSEUM DIVISION, CENTENNIAL BUILDING
SPRINGFIELD, ILLINOIS

TRANSACTIONS OF THE ILLINOIS STATE ACADEMY OF SCIENCE

Vols. 23 and following are free to members, except for mailing costs. Non-members may obtain copies if proper arrangements can be made with the Librarian, Illinois State Museum, Springfield, Illinois.

NOTE: Each member is entitled to only one copy of each issue. Extra separates if desired should be ordered by author at the time proof is returned; if extra copies of the entire volume are desired, special arrangements must be made with the Librarian before the issue goes to press.

SECTION CHAIRMEN FOR 1942-1943

Agriculture O. L. WHALIN, 111 New Agr., Urbana.

Anthropology BEN NUSSBAUM, Fairbury.

Botany K. RICHARD JOHNSON, National College of Education, Evanston.

Chemistry H. W. GOULD, Northern Illinois State Teachers College, De Kalb.

Geography L. A. HOLMES, State Normal University, Normal.

Geology W. E. POWERS, Dept. of Geology, Northwestern University, Evanston.

Physics F. W. COOKE, Illinois College, Jacksonville.

Psychology and Education L. A. PENNINGTON, Physiological Psych. Lab., U. of I., Urbana.

Social Science V. DAKE JOLLEY, Wheaton College.

Zoology H. H. ROSS, Illinois State National History Survey, Urbana.

1943 MEETING: JACKSONVILLE, MAY 7-8

TRANSACTIONS OF THE ILLINOIS STATE ACADEMY OF SCIENCE
Volume 34 June, 1942 Number 4

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STATE OF ILLINOIS
DWIGHT H. GREEN, *Governor*

DEPARTMENT OF REGISTRATION AND EDUCATION
FRANK M. THOMPSON, *Director*

ILLINOIS STATE MUSEUM DIVISION
THORNE DEUEL, *Chief*

ILLINOIS ACADEMY OF SCIENCE
AFFILIATED WITH THE
ILLINOIS STATE MUSEUM

OFFICERS FOR 1942-1943

President: F. M. FRYXELL
Augustana College, Rock Island

First Vice President: L. J. THOMAS
University of Illinois, Urbana

Second Vice-President: WILLIS DERYKE
Illinois College, Jacksonville

Secretary: R. F. PATON
University of Illinois, Urbana

Treasurer: JOHN VOSS
Manual Training High School, Peoria

Librarian: GILBERT WRIGHT
Illinois State Museum, Springfield

Junior Academy Representative: ALLEN R. MOORE, Cicero
Junior Academy Representative (Southern Division): MARY CREAGER, Chester

Editor: GRACE NEEDHAM OLIVER
Illinois Geological Survey, Urbana

In addition to current officers, the Academy Council for 1942-3 includes the two most recent past presidents: V. O. Graham, 4028 Grace St., Chicago, and T. H. Frison, Illinois Natural History Survey, Urbana.

1943 MEETING AT JACKSONVILLE MAY 7-8

Publicity Chairman: GRACE TICKLE, MacMurray College, Jacksonville
Chairman Local Arrangements: WILLIS DERYKE, Illinois College, Jacksonville
Collegiate Section Local Arrangements: W. F. BAILEY, MacMurray College, Jacksonville
Junior Section Local Arrangements: HELEN KAMM, Jacksonville H. S.

Printed June, 1942

REPORTS *of* COUNCIL MEETINGS, 1941-1942

The first meeting was called to order by President Frison in the lobby of Cahn Auditorium, Northwestern University, Evanston, at 8:00 a.m. May 2, 1941. Eight members of the council were present.

Business for the new year was outlined briefly. The committee on Budget (Furrow, Voskuil, Voss) was reappointed. The possibility of forming a committee to promote the formation of a collegiate division in the State Academy was discussed. President Frison asked for suggestions as to personnel for this committee and the names of Wanless, Fernald, Ditman, Gersbacher, Welch, McEvoy at Normal, Carlson at Northwestern, Richardson at Rockford, Walter at Knox, Nelson at Wilson, Gilmore at Wright, Andrews at Herzl were suggested among others. President Frison said he would study the situation and appoint a committee later. The Secretary was instructed to furnish him with a report from the A.A.A.S. on the same subject.

Meeting adjourned at 8:45 a.m. after agreeing that the next council meeting would be held in Urbana in the fall at the time of the High School Conference.

(Signed) R. F. Paton, *Secretary*.

The second council meeting was held at Urbana, Illinois, November 8, 1941 and was called to order at 10:00 a.m. President Frison presided and the others in attendance were Mrs. M. D. Creager, A. R. Moore, F. M. Fryxell, G. E. Ekblaw, Mrs. G. N. Oliver, T. Deuel, R. F. Paton, J. Voss, Miss E. Fernald, J. S. Ayars, and H. R. Wanless.

The minutes were read by the Secretary and approved. Two bills were presented by the Secretary for approval, one in connection with new membership blanks and the other in regard to secretarial expenses. The council approved payment of both bills. The Secretary was instructed to urge section chairmen to be sure that all those presenting papers at the annual meeting should be members or introduced by members of the Academy and that publication in the Transactions is available only to Academy members.

The Council approved of using one page of each Academy publication for announcements of scientific meetings of affiliated societies.

It was agreed that the secretary should draft a letter to all sustaining members urging them to maintain their membership in the Academy.

The report of the activities of the Junior Academy was read by Mrs. Creager. Mr. Astell is to act as chairman of Local Arrangements and the possibility of making use of WPA assistance in putting up exhibits, etc., was considered.

President Frison was empowered to appoint a committee to design an official seal for the State Academy to be designed to fit the needs of the Junior Academy also. He named Miss Meredith Calkins, Carl Mohr, and Miss Audry Hill.

It was also reported that "Science Clubs of America" was being supported by Science News Service and the American Institute of the City of New York but that the Western Electric Company has withdrawn its support from the movement. It was decided that the Junior Academy will not affiliate with "Science Clubs of America" without further investigation. The Council instructed Mrs. Creager to investigate and contact delegate to A.A.A.S. and report back to the Senior Academy.

It was voted that President should appoint one (or two) delegates to the annual A.A.A.S. meeting at Dallas in December.

The date of the next annual meeting of the Academy was officially approved and set for May 7-8-9, 1942. Dr. George Ekblaw, general chairman in charge of arrangements for the 1942 annual meeting, presented a letter from President Willard inviting the Academy to make use of the Union Building and its facilities at that time.

Dr. Thorne Deuel offered to put a notice of the Junior Academy meeting in the forthcoming issue of the *Living Museum* which goes to 5600 individuals interested in science each month. Mr. Astell pointed out that the University Extension Service might be able to help in publicizing the activities for the next meeting of the Junior Academy also. Mr. Allen R. Moore was appointed to visit the State Principals' Meeting at Springfield to be held during the holidays, with the purpose of informing them about the activities of the Junior Academy.

A recess of the Council meeting was called at 11:50 and at the luncheon which followed, the possibilities of a meeting place for 1943 were discussed. It was also suggested that the medical section of the Academy might meet again in May if a suitable sponsor could be found.

Professor Wanless discussed the possibility of organizing a collegiate section of the State Academy as several other academies had done and President Frison appointed a committee to work out plans. Members named for the committee were H. R. Wanless, F. M. Fryxell, A. R. Moore, J. W. Neckers, Miss D. Richardson, L. W. Miller and R. W. Lefler.

The meeting adjourned at 12:50 p.m.

The third council meeting was held at Urbana, Illinois, February 21. The meeting was called to order at 10:15 a.m. with President Frison presiding. The others in attendance were Mrs. M. D. Creager, A. R. Moore, F. M. Fryxell, G. E. Ekblaw, Mrs. G. N. Oliver, R. F. Paton, J. Voss, J. S. Ayars, H. R. Wanless, J. E. Coe, L. J. Thomas, and L. Astell.

The minutes of the last meeting were read by the secretary and approved.

The Treasurer reported that finances were in unusually good shape for this time of the year. There seemed to be every indication that the usefulness of the Academy could be extended.

The Editor reported that the No. 3, Vol. 34, of Transactions, which is about to come out, was in the hands of the printer.

Mrs. Creager and Mr. Moore reported on the affairs of the Junior Academy. Plans for this work are progressing very favorably and both expressed gratification for the support from the High School Principals' Organization and the various groups who are maintaining their sustaining memberships. In connection with the affairs of the Junior Academy, Dr. Thomas reported on the meeting held at Dallas, Texas, as part of the program of the A.A.A.S. Considerable discussion had gone on at this meeting concerning possible cooperation between "Science Clubs of America" and the junior clubs of the Illinois Academy. A more detailed report on this situation was promised for the annual meeting. The council decided that the Illinois Academy would be glad to cooperate in any manner possible, subject to the approval of the committee set up to study such cooperation by the A.A.A.S. Mrs. Creager reported that the Southern Division of the Illinois Academy of Science expected to hold a sectional meeting on the 11th of April at Carbondale. It was hoped that groups winning special recognition at this sectional meeting would attend the state-wide meeting to be held at Urbana May 8 and 9.

Mrs. Creager was instructed to write the "Science Clubs of America" in Illinois, inviting them to join with the Junior Academy at our annual meeting.

The committee to design a seal to be used by all branches of the Academy including the Junior Academy, consisting of Miss Meredith Calkins of Illinois Geological Survey, Miss Audry Hill of Carbondale, and Mr. Carl Mohr of Natural History Survey suggested a design which was submitted and discussed. The Council felt that the design was appropriate in idea but could well be simplified in detail, and a plain seal with ribbons to be put on the Junior Academy certificates of Award could be used for this year's meeting. Mr. Ayars and Mrs. Oliver were instructed to attend to this.

Dr. Wanless reported on his work in forming the collegiate section. Many favorable replies had already been received from the colleges of the State and the Council was pleased to note that the collegiate division would undoubtedly be a success. Thirty-three papers had already been reported as available and these fitted logically into three divisions; one on biological sciences, one on earth sciences, and one on physical sciences. Dr. Ekblaw moved and it was seconded that the council authorize the formation of a collegiate section which should be open to all undergraduates interested in science in all of the colleges of the State. The motion after careful discussion was carried unanimously.

The plan for the current year was to invite every undergraduate organization to take part in this meeting and send one voting delegate for the purpose of setting up the organization for future years. It was agreed that the number of persons from any college or group attending the spring meeting should not be limited, and any college where no organized science club existed could send a representative to this meeting. It was not felt that membership in the Academy was essential to take part in this meeting, but that science clubs should be encouraged to affiliate and it was pointed out by the secretary that it would be possible for them to receive the publications of the Academy if interested groups paid the minimum fee of $1.00.

The Council adjourned at 11:55 a.m. and reconvened at a luncheon at 12:15 at the Illini Union. At the luncheon meeting there was some further discussion on the organization of the collegiate division. Subjects also discussed were possible meeting places for next year, and details of the spring meeting and publicity for it. Arrangements seemed to be well under way.

President Frison reported that plans for the general program and evening lectures were being made and that he hoped to arrange for a separate lecture for the Junior and Senior Academies on Friday evening. The banquets for the Junior and Senior Academies were also approved for Friday evening. Due to the difficulty of obtaining satisfactory transportation and the expense connected with such plans, it was agreed that the Saturday morning program might well be given over to open-house programs and inspection trips of various laboratories and museums on the local campus. President Frison was instructed to investigate the possibility of getting cooperation from the University departments.

In discussing the possibility of a place of meeting for 1943, the secretary was advised to get in touch with interested people at Harrisburg, Jacksonville and Carbondale. The secretary reported that due to the present national emergency, plans for reorganization of the

medical section which had been considered for this year were postponed.

A request for support of publication expense from the research funds of the Academy submitted by Malcolm Reid was denied, as the funds available are supplied entirely by the A.A.A.S. and the local academies are not permitted to grant them for such projects.

Proper time for the annual business meeting was discussed but no final decision was made.

The Secretary was instructed to investigate the possibility of getting reduced rates for railroad fares by people attending this meeting, although it was not thought that such would be possible.

The meeting adjourned at 2:00 p.m.

The fourth council meeting convened at dinner at 6:30 p.m., May 7, 1942, at the Illini Union Building, Urbana, and present were Dr. E. Fernald, H. R. Wanless, George E. Ekblaw, G. Wright, F. M. Fryxell, T. H. Frison, L. J. Thomas, Mrs. Mary Creager, John Voss, E. L. Stover. Mrs. G. N. Oliver, J. Ayars, and R. F. Paton.

The business of the council was transacted in the private dining room immediately after dinner. Minutes of the third council meeting were read and approved. The report on the arrangements for the annual meeting which was scheduled to begin Friday was given by Dr. George Ekblaw, chairman of the committee on local arrangements, who stated that all the arrangements seemed to be in excellent order and expressed great appreciation for the cooperation rendered by C. W. Lyon, assistant director of the Physical Plant, University of Illinois.

The resignation of our Academy librarian, Dr. Thorne Deuel, was received and accepted with regret. Dr. Deuel stated that he had received orders to report for duty in the Army. A previous communication from Dr. Deuel on the importance of keeping the publications of the Academy prompt on account of the possibility of losing our mailing permit was read. The editor was instructed to do everything necessary to insure this promptness. Mr. Gilbert Wright was elected as successor to Dr. Deuel.

The Treasurer gave a brief report which indicated that the Academy affairs were on a very sound financial basis and acceptance and approval of the report was very enthusiastic.

The Editor gave a brief report seconding the need for prompt publication of the various numbers of the Academy Transactions.

Mrs. Creager reported briefly on the plans and activities of the Junior Academy during the current year and nature of the program which seemed to be indicated for next year.

Dr. L. J. Thomas, Chairman on the A.A.A.S. special committee on relations with Science Clubs of America, gave a brief report on a meeting of this committee held on March 28, at Indianapolis.

Several invitations to hold the 1943 meeting were read and discussed. It was finally voted to accept the invitation from Jacksonville as being the most appropriate, although several of the council felt it would be nice if the Academy could meet in all of the places since the invitations from other towns were very cordial. The time of the 1943 meeting was voted upon and is to be May 7 and 8, 1943. It is felt that every effort should be made to go ahead with the meeting as a portion of the activities the Academy could carry out helping to fill the present need for people trained in science.

Dr. Wanless reported on the successful plans for the new Collegiate Section. Following this report it was moved and seconded that the relationship between the Collegiate Section and the Academy be administered by an advisory committee, consisting of one representative from the faculty of each college cooperating with the group. To be eligible for membership on this council the representative must be a member of the Academy. After a brief discussion the motion was carried. There was also some discussion of the possibility of inviting members of the Collegiate Section to submit papers for publication in the Transactions and it was felt that this would be highly desirable if the research reported was original. It was pointed out, however, that anyone who wished to avail himself of this privilege, would have to be a member of the Academy.

A letter from the former chairman of the membership committee, Major L. C. McCabe, was read. Major McCabe called the attention of the council to the fact that it was difficult for members of the Academy in the national service to maintain a suitable address to which copies of Transactions could be mailed, and suggested that these people be relieved of the responsibility of paying membership dues. The council felt that in view of the practice of keeping all members on the roll until they were delinquent at least three years, the waiving of dues was unnecessary. It was also felt that some of the members might want to maintain their files of Transactions but that the Academy could not well afford to furnish these to non-paying members. After some further discussion, it was moved that no one in the national service should be dropped from the Academy rolls for non-payment of dues, but that Transactions be mailed only to those who kept the Academy informed of their address. This

motion was seconded and during the discussion the fact was also brought out that any member could always complete his files of Transactions by notifying the secretary of his address but that the Academy could furnish these only after the past dues had been paid; also, following the usual custom, a member could always re-instate himself simply by renewing his payments. It was felt that continuing this custom would work out satisfactorily to all concerned in the present case. There being no further discussion, the motion was voted.

A letter from former president V. O. Graham with a very interesting map which he had prepared showing the distribution of membership of the Academy in the State, was submitted. This map showed that the Academy members were located largely in a few areas of the State. The Council agreed that every effort should be made by the Academy to extend its services more broadly to the people of the State. The discussion of the possibility of this was referred to the secretary to pass on to the committee on membership. There being no further business, the Academy adjourned at 9:30 p.m.

(Signed) R. F. Paton, *Secretary*.

REPORTS *of the* 35TH ANNUAL MEETING

University of Illinois, Urbana, Illinois

BUSINESS MEETINGS, FRIDAY, MAY 8, 1942

The preliminary business meeting of the Illinois State Academy of Science was called to order by President Frison at 9:00 a.m. in Lincoln Hall Theatre. Business of the meeting consisted in the appointment of three of the committees for the day. These were: Committee on Resolutions, Committee on Nominations, and Auditing Committee. The personnel of these committees was instructed to report of the general business meeting in the afternoon. The following committees and members were appointed:

Nominating Committee: E. L. Stover, Dr. E. Fernald, Dr. V. O. Graham, Dr. H. R. Wanless, Dr. J. Neckers, Dr. Clarence Bonnell.

Committee on resolutions: H. J. Van Cleve, F. M. Fryxell, C. A. Bonnell.

Auditing Committee: Walter W. Thomas, John Q. Sapp, Gray Adamson.

There being no further business for this session, the meeting adjourned until 5:00 p.m.

The final business meeting was called to order by President Frison at 5:00 p.m. in Lincoln Hall Theatre. The minutes of the preliminary meeting were read and approved and the remaining business consisted of reports of officers and committees.

The Treasurer's report was read and approved. The report of the Auditing Committee submitted by W. W. Thomas was also read to the Council and approved.

Dr. Stover reported for the nominating committee. Following a short discussion in which further nominations were called for the committee's selections were elected.

Dr. H. J. Van Cleve reported for the Resolutions Committee and the committee's work was read and approved.

The Secretary pointed out that reports of all the other committees will be published in the next number of Transactions and that reading of them could be omitted to save time. This suggestion was approved.

Outgoing Preident Frison then turned over the seals of office, so to speak, to incoming President Fryxell, who responded with brevity, concision, and sincerity to the request for a speech. There being no further business, the meeting adjourned at 5:30 p.m.

(Signed) R. F. Paton, *Secretary*.

LOCAL ARRANGEMENTS

Most of the work and duties of a committee on local arrangements for a convention are so obvious that they merit no special report, but certain features of the 35th annual meeting of the Illinois Academy of Science seem to merit special mention for record.

First, the various sessions of the Academy required four large meeting halls—one for the Friday morning general session and the Friday afternoon business session of the Academy, one for the general meetings of the newly organized Collegiate Section, one for the regular meeting of the Junior Academy, and one for the public lecture Friday evening—all equipped with projection facilities; a large hall for the Junior Academy exhibits; rooms for registration; three rooms for special meetings Friday afternoon; and fourteen rooms, with projection facilities, for the Friday afternoon sectional meetings. The University of Illinois made all these necessary accomodations available, they provided projection equipment and operators to the limit of their availability, they provided furniture and other equipment, and they provided all the necessary labor to

transport the furniture back and forth and to put it in place—all without any expense to the Academy.

Second, five group meals were required—the regular Academy luncheon, with tables specially reserved for the physicists and for the geographers; the regular Academy banquet, the Junior Academy luncheon; the Junior Academy banquet; and the Social Science luncheon. The first two were provided by the Illini Union on the University campus; the Junior Academy meals were provided by the University Place Christian Church, adjacent to the campus; and the Social Science luncheon was provided by the University Y.M.C.A., also adjacent to the campus. Thus ultra-convenience was served.

Third, local representatives were delegated to be prepared to render each of the sectional chairmen any assistance necessary during the sectional meetings, to assure satisfactory and efficient conduct of the meetings. These representatives also assumed the responsibility of providing projection equipment and operators at such sectional meetings as the University could not provide.

Fourth, the idea of having Saturday inspections of University and State Survey laboratories, museums, etc., instead of field trips was an innovation, but it was received enthusiastically by the Deans of the various colleges, the Heads of the various departments, and the Curators of the various museums of the University and the Chiefs of the State Surveys, all of whom made the necessary arrangements and provided the necessary guides for the 22 trips that they scheduled.

Fifth, concerning attendance, about 250 people registered at the regular Academy session; many more attended without registering; a total of about 300 attended the afternoon sectional meetings; 138 were served at the regular Academy luncheon; 173 were served at the Academy banquet; about 1000 people attended the public lecture Friday evening; and almost 500 people attended the inspection trips Saturday forenoon, composing groups ranging in number from 3 to more than 60.

It should be evident from the above listings what a host of people contributed to the success of the 35th annual meeting of the State Academy of Science. They are too numerous to mention individually, but their assistance and willing cooperation is nevertheless greatly appreciated. However, individual credit must be given to Mr. C. W. Lyon of the University of Illinois Physical Plant, whose cordial cooperation in making arrangements immeasurably lightened the task of the committee; to Mr. S. E. Griffith, also of the University Physical Plant, who superintended the arrangements; and to Mr. Louis A. Astell, who assumed responsibility for the arrangements for the Junior Academy. The special assistance of the State Natural History Survey and State Geological Survey in providing stenographic and clerical help for registration and other services and that of the Champaign Chamber of Commerce in providing badges for registrants of the Academy is also gratefully acknowledged.

Respectfully submitted,

(Signed) George E. Ekblaw, *Chairman*.

PUBLICITY

Following is a brief report on the publicity prepared and issued by the Publicity Director for the thirty-fifth annual meeting of the Illinois State Academy of Science held at the University of Illinois, May 7, 8, and 9, 1942, Urbana, Illinois.

Little effort was made to acquaint the public with the 1942 meeting until the February Council Meeting had been held. A local newspaper strike in February somewhat curtailed the publicity efforts at that time. Formation of a new collegiate section gave opportunity for the first general release, February 23.

A chronological listing of the releases follows:

1. Mimeographed release—"Formation of a collegiate section"—250 words, to 95 Illinois dailies, 9 out-of-state dailies, 39 collegiate papers, 3 press associations, Science News Letter, 113 Illinois weeklies.

2. Typed release—"War will mingle conspicuously"— April 12, 1942, 492 words to 5 press services, Science Service, 5 radio stations or systems, 14 Illinois and out-of-state dailies. (Programs sent to most of these.)

3. Typed release—Karl P. Schmidt story and mat—April 16, 1942, 294 words, to 4 press services, 23 Illinois and out-of-state dailies.

4. Typed releases to specific cities dealing with their local residents taking part in meeting—37 cities, 5 publicity directors of universities, 77 newspapers, including college publications, 3 individuals—April 23, 1942. Also mats of President of Academy, 24 mats and 12 photos with this story or previously. A different lead in each of 26 stories, approximately 450 words in each story.

5. Mimeographed release—"Over 700 high school students"— May 2, 1942, 336 words, to 6 press services, 104 Illinois and out-of-state dailies, 21 radio stations, 33 Illinois college papers, 109 county seat weeklies, 219 weeklies other than county seat, 16 individuals, 3 magazines.

6. Mimeographed release—"Leading scientists of the state"—May 3, 1942, 378 words, to 104 Illinois and out-of-state dailies, 6 press

services, 21 radio stations, 33 Illinois college papers, 109 county seat weeklies, 219 weeklies other than county seat, 16 individuals, 3 magazines.

7. Typed release—"University of Illinois scientists"—May 6, 1942, 980 words, to 4 Illinois dailies.

8. Collegiate supplement to program story above—May 7, 1942, to local dailies—Courier, News Gazette, and Illini.

9. Typed release—"Dr. T. H. Frison, Chief" —May 6, 1942, 298 words, to 3 local dailies.

10. Typed release "Scientists from all parts of the state"—May 7, 1942, 455 words, to 3 press associations, 9 Illinois and out-of-state dailies.

Abstracts or copies of 40 of the papers were supplied upon request to Science Service and 44 to the University of Illinois publicity office for ready reference by reporters. The numbers represent all the papers of possible news value received in time to make copies for distribution before the meeting. About a dozen of the more important papers or abstracts were sent upon request to the Associated Press in Chicago and the United Press in Springfield.

Copies of the President's speech and excerpts from Mr. Schmidt's speech were supplied to three press associations, to the three local papers, and to the University's publicity office.

Material was furnished to a reporter sent by the Chicago *Daily News* to cover the meeting.

At the time of the meeting, information on attendance, awards, and election of officers was furnished to local representatives of both the Associated Press and the United Press for transmission by wire, as well as to the three local papers. No mail releases were prepared on these subjects, as they would have reached papers too late to be of use.

Although no clipping service was employed, clippings collected informally indicate that the releases, particularly the release of April 23, were widely used.

Respectfully submitted,

(Signed) James S. Ayars,
Publicity Director.

REPORT CONCERNING THE ESTABLISHMENT OF A COLLEGIATE SECTION

After authorization by President Frison at the Council Meeting in November, 1941, preliminary conferences were held with members of the faculties of science departments and representatives of the organized student science clubs and fraternities at the University of Illinois. The projected Collegiate Section was intended to fill the gap between the junior and senior divisions of the Academy and to provide an outlet for reporting the results of researches by undergraduate students of the Colleges and Universities of the state. A circular letter was sent early in January to one representative of the science faculty at each of 50 colleges or universities in Illinois to inquire into the feasibility of establishing such an organization, to gather information about organized science clubs or societies, and to learn the names of students carrying on researches which might be reported at an inaugural meeting.

About 30 replies were received to this letter, manifesting considerable interest in the organization. Some wrote that the Academy could serve the interest of the smaller colleges of the state better through a Collegiate Section than through any of its existing divisions. Some suggested that although no student science organization existed in the colleges this inquiry had provided impetus toward the establishment of a science club. On February 21, 1942, these preliminary findings were reported to President Frison and the Council, and positive authorization was given at that time for the inauguration of a Collegiate Section at the Urbana meeting May 8 and 9, 1942. A second circular letter was sent reporting the interest manifested in replies to the first letter and requesting definite information about papers or projects which were to be presented at the Urbana meeting. Eventually there were received 37 titles of papers by students from 15 colleges or universities on such widely diverse subjects as "The New Chicago Subway and Chicago Soil," "Mounting Pig Skeletons," "Building a Geological Museum," "Ibo Ethnography and Primitive West African Education," "Electric Well Logs," and "A Working Model Demonstrating the Cyclotron Principle." The program was divided into three sections in order that each speaker might have as much as 10 minutes for presenting his or her paper. Papers in related fields were combined into the same section.

The inaugural meeting was held Friday, May 8 in Rooms 100, 213, and 223 Gregory Hall at the University of Illinois. Prof. B. S. Hopkins, a former president of the State Academy delivered an introductory talk on "Research Opportunities for the Undergraduate Student in Science." Prof. Hopkins suggested the possibility of a competitive study of the same problem by students at different colleges as an incentive toward the achievement of greater excellence in research results. The three section meetings were run under the chairmanship of the following representatives of science clubs or groups at the University of Illinois:

Mrs. Martha Leavenworth, Botany Department.

Mr. Frank Hasbrouck, Hexapoecia Club, Entomology Department.

Mr. Roy Barber, Physiology Department.

Miss Jenny Bonnett, Bacteriology Club.

Mr. William Oesterling, Cyclothem Club, Geology.

Miss Eleanor Hutchison, Iota Sigma Pi, Chemistry.

All but three of the 37 papers were presented. The attendance at the individual section meetings ranged from about 20 to 40. There would have been a larger attendance except that the meetings were held at the same time as the sectional meetings of the Senior Section of the Academy.

Following the sectional program an organization business meeting was held attended by about 30 students representing 10 colleges or universities. There was much discussion of the program of the Collegiate Section and the methods of selecting student officers and an executive committee. A committee of 10 consisting of one student from each of the colleges or universities represented was selected to draft a constitution and report this at the next annual business meeting, and to serve as an executive committee for the coming year. The following were selected:

Ida Wright, Morton Junior College, Cicero.

Anna Mae Jordan, St. Francis College, Joliet.

Patricia Borgstrom, Rosary College, River Forest.

Virginia MacWethy, Rockford College, Rockford.

Amy Jones, Southern Illinois State Normal, Carbondale.

Mr. Stringer, Illinois State Normal, Normal.

Mrs. Martha Leavenworth, University of Illinois, Urbana.

Carter Christie, Illinois Wesleyan, Bloomington.

Orland A. Ponzio, Loyola University, Loyola.

Eugene Grassel, Blackburn College, Carlinville.

This committee chose Mrs. Martha Leavenworth, Department of Botany, University of Illinois, as chairman. The committee met at once and drafted a considerable part of the constitution, modeling it in part after the constitution of the Collegiate Section of the Texas Academy of Science, which has been in operation for about five years. The Council of the Academy at its meeting May 7 authorized the selection of an advisory committee of the Collegiate Section to consist of one representative of the science faculty of each college or university in the State of Illinois.

Many of those attending the Collegiate Sections participated in the annual dinner of the Academy Friday evening and attended the evening public lecture and some of the conducted trips through the scientific laboratories at the University Saturday morning.

REPORT OF THE EDITOR

Quarterly issues of the *Transactions* were published during the past year as follows:

Vol. 33, No. 4, June, 1941, 24 pages. Contains a record of minutes of the four Council meetings held during the year; business transacted at the annual meeting at Evanston in May 1941; reports of committees and delegates; and results of Junior Academy competition of exhibits at Evanston. Cost of publication: $144.80.

Vol. 34, No. 1, September, 1941, 38 pages. Contains the address of the outgoing president, that of a past president, and special papers presented at the May meeting. Is accompanied by the Index for Volume 33. Cost of publication: $236.59.

Vol. 34, No. 2, December, 1941. 200 pages. Contains 96 papers ,in full or in abstract form, which were given at the May meeting at Evanston, and lists 46 by title. 56 illustrations. Cost of publication: $1129.96.

Vol. 34, No. 3, March, 1942, 15 pages. Comprises the preliminary and final forms of the program for the annual meeting held this year in Urbana on May 8 and 9. Cost of publication: $114.55.

State funds, which are available to the Academy through the budget allotted to the Illinois State Museum for publication, paid for the September and December issues, Academy funds for the other two

Respectfully submitted,

(Signed) Grace Needham Oliver, *Editor.*

REPORT OF THE LIBRARIAN

During the year the Librarian has attended to the distribution of Transactions Volumes 33 number 4 to Volume 34 number 3 inclusive. Of these numbers, the following surplus copies are now on hand:

Volume 33 number 4	248
Volume 34 number 1	248
Volume 34 number 2	249
Volume 34 number 3	125

A total of 181 copies of the Transactions were sent out in response to special requests. Many of these requests came from new members and from institutions on the exchange list.

The mailing list has been kept up-to-date with many additions and corrections during the year. Names of members whose Transactions were returned to the Librarian have been temporarily dropped from the mailing list. Members are urged to send prompt notice to the Librarian of any change of address.

The status of out-of-print issues and of publications received in exchange remains essentially the same as indicated in the 1941 report of the Librarian, hence a listing of these publications is not included at this time.

Due to the fact that I am soon to be enrolled in the Army, my resignation as Librarian of the Academy was submitted to the council on April 11th of this year. Needless to say, I much regret that I must sever my connections with the Academy at this time. It is my hope that I may sometime renew what has always been a pleasant association with this organization.

Respectfully submitted,
(Signed) Thorne Deuel, *Librarian.*

REPORT OF TREASURER

For the fiscal year May 1, 1941 to April 30, 1942

Receipts

Balance on hand April 30, 1941		$ 815.62
Dues and initiation fees:		
Annual members	$805.90	
Life member	25.00	
Affiliated societies	17.00	847.90
Sale of Transactions		3.00
Editorial and excess pages fees		138.50
Research grants by the A.A.A.S.		200.00
Luncheon tickets—Evanston		206.00
Junior Academy:		
Dues and initiation fees	59.60	
Sustaining memberships	233.00	292.40
		$2,503.42

Expenditures

Expenses of the Annual Meeting—Evanston, 1941:		
Banquet, buses, motion pictures, etc.	329.29	
Officers' expenses	98.49	
Section Chairmen, expenses	33.85	461.63
Expenses of Treasurer		27.82
Postage and Transportation of Transactions		22.30
Printing of Transactions		144.80
Expenses of Secretary		27.13
Printing of Membership Blanks		14.75
Secretary, honorarium		150.00
Editor, honorarium		150.00
Conservation Council		2.00
Returned checks and bank charges		6.47

Research grants:		
P. H. Kinsell	50.00	
C. L. Furrow	50.00	
C. Clayton Hoff	50.00	
J. Fisher Stanfield	50.00	200.00
Junior Academy:		
Officers' expenses	61.26	
Trophies	46.56	
Exhibit expenses	36.52	
Printing	58.64	
Science Aids	25.00	227.98
Balacne in Commercial Merchants National Bank and Trust Company of Peoria		1,068.54
		$2,503.42

Statement of Resources, April 30, 1942

Balance in Commercial Merchants National Bank and Trust Company, Peoria	1,068.54
Certificate of Deposit No. 760 for Meyer Block Bonds (Chicago)	150.00
Certificate of Interest No. 13 for Forbes Building (Chicago)	150.00
	$1,368.54

The membership of the Academy consists of 64 life members, 107 new members, 12 sustaining members, 523 members paid up to and including the year 1942, 118 members one year in arrears, 78 members two years in arrears, and 46 members three years in arrears.

The total membership not including the members who are three years in arrears is 992. During the year 15 members have resigned, 7 have died, and 45 have removed leaving no forwarding address.

The Academy has added 7 new Junior Academies, 24 are fully paid up, 15 are one year in arrears, 8 two years in arrears, and 7 three years in arrears.

The present financial status is the best in the history of the Academy. The sustaining memberships and especially the one from the Illinois High School Association have greatly benefited the Junior Section.

Respectfully submitted,

(Signed) John Voss, *Treasurer.*

This is to certify that we have examined the accounts of John Voss, Treasurer of the Illinois State Academy of Science, for the year May 1, 1941 to April 30, 1942 and find them correct. The balance of $1068.54 is on deposit with the Commercial Merchants National Bank and Trust Company of Peoria, Illinois.

(Signed) Walter W. Thomas
Chairman, Auditing Committee
A. G. Adamson
John Q. Sapp

REPORTS *of* COMMITTEES

Your Committee on Conservation has attempted to bring before the Senators of Illinois a realization of what the reduced budget passed by the House of Representatives for the work of the U. S. Fish and Wildlife Service would mean as an obstacle to the program in national conservation.

Particular attention has been called to the complete elimination of the program on the food of birds and mammals and the Senators have been respectfully requested to use their influence in seeing that the bill, when it comes before the Senate, should not include provisions that would seriously cripple the program of conservation as a continuing aspect of the work of the Fish and Wildlife Service.

(Signed) H. J. Van Cleave,
Chairman.

The Academy Conference of the A.A.A.S. held its fifteenth annual session in the Baker Hotel in Dallas, Texas, on the afternoon of December 29, 1941.

The formal program consisted of two papers, one by Dr. E. C. Faust, (New Orleans Academy) on "A Resume of A.A.A.S. Research Grants," and the other by Dr. J. C. Godbey, (Texas Academy) on "The Organization of a Collegiate Division of the Texas Academy of Science."

Dr. Faust's paper presented the following recommendations:

1. Serious consideration should be given to allotment of rewards with reference to responsibility of grantees to provide annual (or semi-annual) progress reports to Research

Grant Committee or Secretary of Academy. (This in respect to very little evidence that research projects reach the publication stage except as abstracts in Academy Transactions.; the Secretaries have great difficulty in obtaining such reports from Grants Committees or directly from grantees; in some instances utter disregard on the part of grantees for requested information.)

2. Closer cooperation is needed between Research Grant Committee and Secretary of Academy. The Committee and Secretary should have readily available up-to-date duplicate files of status of each grant from 1935.

3. In the future Mr. Woodley's office of the A.A.A.S. should be the clearing office for all such reports to the Academy Conference.

A Committee to study the Junior Academy situation was selected as follows: Lyell J. Thomas, *Chairman* (Illinois Academy); G. W. Prescott (Michigan Academy); William G. Camp (Maryland Academy); G. L. Cross (Oklahoma Academy); R. C. Smith (Kansas Academy); Mrs. E. Barry Walker (Commerce, Texas); H. E. Enders (Indiana Academy); E. C. L. Miller (Virginia Academy); D. B. Lawrence (Minnesota Academy); and Anna A. Achneib (Kentucky Academy). A preliminary meeting of this committee was held in Indianapolis.

(Signed) Lyell J. Thomas,
Delegate.

Chicago Conservation Council. The past year has encountered changing ideas for work in conservation, one type of observer takes the position that all must be set aside, that all our progress across the years must be forgotten for the duration of the war, another observer looks far beyond to a time when wars are over, when people must have preserved for character building enjoyment, for vacation life, the surroundings which are most needed. We sincerely hope that the majority of the people of Illinois have this latter viewpoint for much can be done even in war time to improve conservation areas. Illinois must indeed have the Waukegan dunes, an increased area of Apple River, additions to Starved Rock, strip-mine areas, and an increasingly large National Forest area to afford recreational area for the people. May the thinking people of Illinois never forget to project their thinking beyond the time of war that we may never fail to have ready large production area of National forest.

(Signed) Verne O. Graham,
Chairman.

The nominating committee begs to submit the following names* for officers and committee members of the Academy for 1942-1943:

President: F. M. Fryxell, Augustana College, Rock Island.

First Vice-President: L. J. Thomas, University of Ill., Urbana.

Second Vice-President: Willis DeRyke, Illinois College, Jacksonville.

Secretary: R. F. Paton, University of Ill., Urbana.

Treasurer: John Voss, Manual Training H. S., Peoria.

Librarian: Gilbert Wright, Ill. State Museum, Springfield.

Editor: Grace Needham Oliver, State Geological Survey, Urbana.

Delegate to A.A.A.S.: L. J. Thomas, University of Ill., Urbana.

Delegate to Conservation Council: V. O. Graham, 4028 Grace St., Chicago.

Junior Academy Representatives:

General Chairman: Allen R. Moore, Cicero.

Southern Division: Mrs. Mary Creager, Chester.

1943 Meeting at Jacksonville

Publicity Director: Grace Tickle, MacMurray College.

General Chairman, Local Arrangements: Willis DeRyke, Illinois College.

Collegiate Section Local Arrangements: W. F. Bailey, MacMurray College.

Junior Section Local Arrangements:
Helen Kamm, Jacksonville, H. S.

Committees

Conservation:

M. M. Leighton, State Geological Survey, Urbana, *Chairman.*

W. H. Haas, Northwestern University, Evanston.

N. M. Gersbacher, Carbondale.

D. D. Lansden, Cairo.

Paul Houdek, Robinson.

George Bennett, State Natural History Survey, Urbana.

R. S. Smith, University of Ill., Urbana.

W. C. Allee, University of Chicago.

E. L. Stover, Charleston.

Rev. Geo. M. Link, Grafton.

Legislation & Finance:

Fay-Cooper Cole, University of Chicago, *Chairman.*

H. B. Ward, University of Ill., Urbana.

F. W. Aldrich, 1506 E. Washington St., Bloomington.

E. S. Bastin, University of Chicago.

Affiliations:

H. R. Wanless, University of Ill., *Chairman.*

**Report adopted as read, and slate considered elected without change.*

Ildrem Daniel, Chicago Schools.
V. F. Swaim, Bradley Polytechnic Institute, Peoria.
Glen Warner.
H. K. Gloyd.
Mrs. Geraldine Nilson.
Percival Robertson, Principia College, Elsah.

MEMBERSHIP:

J. E. Coe, 2024 Sunnyside, Chicago, *Chairman.*
J. H. Reedy, University of Ill., Urbana.
N. D. Cheronis, 5556 Ardmore Ave., Chicago.
J. F. Stanfield, Chicago Normal.
George E. Ekblaw, State Geological Survey, Urbana.
Floyd Barloga, Peoria.
G. W. Hufford. Joliet.
W. B. Welsh, Carbondale.
D. L. Eaton, De Kalb.
K. G. Larson, Augustana College, Rock Island.
Orlando Park, Northwestern University, Evanston.
G. N. Jones, University of Ill., Urbana.
Fred R. Cagle, Carbondale.
Carl Ekblad, Moline.

CONSERVATION OF ARCHAEOLOGICAL AND HISTORIC SITES:

Fay-Cooper Cole, University of Chicago, *Chairman.*
F. W. Aldrich, Bloomington.
M. J. Herskovits, Northwestern University, Evanston.
M. M. Leighton, State Geological Survey, Urbana.
J. B. Ruyle, Champaign.
H. B.Ward, University of Ill., Urbana.
Bruce W. Merwin, Carbondale.

RESEARCH GRANTS FROM A.A.A.S.:

L. H. Tiffany, Northwestern University, Evanston, *Chairman.*
Carl G. Hartman, University of Ill., Urbana.
H. E. Way, Knox College, Galesburg.
O. L. Railsback, Charleston.
B. S. Hopkins, University of Ill., Urbana.
R. L. Beyer, Carbondale.

BUDGET:

C. L. Furrow, Knox College, Galesburg.
John Voss, Peoria.
W. H. Voskuil, State Geological Survey, Urbana.

PUBLICATIONS:

The President.
The Secretary.
Neil E. Stevens, University of Ill., Urbana.
H. J. Van Cleave, University of Ill., Urbana.

ECOLOGICAL BIBLIOGRAPHY:

A. G. Vestal, University of Ill., Urbana.

HIGH SCHOOL SCIENCE AND CLUBS (JUNIOR ACADEMY):

General Chairman: Allen R. Moore, Cicero.
Assistant: Miss Aleta S. McEvoy, Rockford H. S.
Chairman of Exhibits: Dwight L. Barr, Chicago.
Assistant: Miss Nellie Bates, Champaign H. S.
Chairman of Judging: Robt. L. Smith, Herron Twp. H. S.
Assistant: Dale McNeal, Normal Community H. S.
Radio Service: Rosalie M. Parr, University of Ill., Urbana.
Correspondent: Audry Hill, University H. S., Carbondale.

SOUTHERN DIVISION, JUNIOR ACADEMY:

General Chairman: Mary Creager, Chester.
General Science Chairman: Audry Hill, University H. S., Carbondale.
Biology Chairman: Elizabeth Buell, Anna-Jonesboro, H. S.
Physics Chairman: Eldon Walter, Galatia H. S.

Respectfully submitted,
(Signed) E. L. STOVER, *Chairman.*

Committee on Publications: It is thought best to continue the editorial fee in connection with publication of papers, and a careful checkup of authors should be made each year to be sure they are members in good standing before their papers are sent to the editor. There has been very fine cooperation on the part of the authors in reading their proof promptly—better than in previous years. Also, more authors ordered reprints this year: ½ of the total number publishing, as against ⅓ last year. Blanks were sent all authors who might wish to publish abstracts in *Biological*

Abstracts. Fifteen such abstracts came through the editor's hands, and probably some more were sent directly to Philadelphia.

Respectfully submitted,

(Signed) T. H. Frison
R. F. Paton
Neil E. Stevens
H. J. Van Cleave

The Committee on Research Grants of the Illinois State Academy of Science recommended that grants-in-aid be provided for the following individuals in the amounts indicated:

To Dr. W. M. Reid of Monmouth College for the purchase of a centrifuge, and of certain additional items of equipment, to be used in investigating the Glycogen Content of Intestinal Parasites, with particular reference to the influence of the nutritive status of the host..... $ 75.00

To Dr. W. W. Crawford of Blackburn College to cover the cost of transportation, and of materials required in a study of the life history of trematodes..... 50.00

To Dr. C. C. Hoff of Quincy College to purchase supplies necessary to enable him to extend his researches on ostracods..... 50.00

To Dr. M. E. Britton of Northwestern University for supplies required in an investigation of environmental conditions which permit the persistence of bog communities..... 51.50

Total..... $226.50

Attention should be called to the fact that the number of applications received during the current year was not so large as one might have anticipated. Although the grants are always small, one would expect them to be sought by a considerable number of individuals. Possibly the fact that a research fund exists is not appreciated by many of the members of the scientific faculties in the smaller institutions of the state. It is hoped that each member of the Academy will give as much publicity to this matter as possible, so that greater interest may be manifested in the future.

(Signed) W. C. Rose, *Chairman.*

The Committee on Resolutions begs leave to submit the following report:

Whereas: Our nation now finds itself confronted with an unprecedented emergency, the outcome of which threatens as never before the democratic principles which this country holds dear

Be it resolved: that the Illinois State Academy of Science pledge its whole-hearted endeavors, collectively and individually, to make itself useful in whatsoever manner it may be called upon to act.

Whereas: The success and the future development of this Academy depends upon its influence upon the citizens and the scientific programs in this State, The Academy expresses its gratification on the successful organization of a new group in its midst—the Collegiate Section. The Academy looks forward to this section for the support of its ideals and objectives.

Whereas: the modern scientific developments in the field of health conservation have assumed great importance in society and the material conservation of human health and welfare represents one of the crowning aims of society, and

Whereas: both students and teachers of medicine, dentistry, and pharmacy have come to question the suitability of certain phases of pre-professional training for these fields,

Be it resolved: that the proper authorities be instructed to take appropriate steps for the incorporation into the program for the annual meeting of the Academy in 1943, of a Symposium on pre-professional education leading to the fields of medicine, dentistry, and pharmacy, with representation from the teaching faculties at both levels of training.

Whereas: The following have contributed toward making these meetings an outstanding success:

The officers of the Academy
The Administration of the University of Illinois
The various Departments of the University
The Physical Plant of the University
The Lectures Committee of the University
The Housing Division of the University
The Illini Union Management
The State Scientific Surveys
The Champaign Chamber of Commerce, and

Whereas: the following individuals have aided much in the success of the meetings:

President A. C. Willard
Dr. George E. Ekblaw
Mr. C. W. Lyon
Mr. S. E. Griffith
Mr. James Ayars
Mr. Louis Astell

Be it resolved: that the Academy express its appreciation to these and to all others who by their efforts have helped in arrangements for these meetings.

Whereas: In the times of National stress and emergency there is often a tendency to curtail the support of scientific research and activity

Be it resolved: That the Academy go on record as favoring the maintenance of these activities at as high a level as feasible with existing conditions.

Whereas: The Illinois State Academy of Science has lost, by death, the following esteemed members during thepast year:

Dr. M. J. Andrade, Chicago.
Mr. Frank C. Baker, Urbana.
Dr. Eugene Davenport, Woodland, Michigan.
Dr. L. F. Gruber, Maywood.
Mr. A. Malinovszky, South Gate, California.
Dr. James A. Melrose, Decatur.
Dr. Herman S. Pepoon, Chicago.
Dr. Frank Smith, Hillsdale, Michigan.

Be it resolved that the Academy spread on its records a note of appreciation of the services of these members to science and to society and that the Secretary be instructed to express the sentiments of the Academy to the families of the deceased.

(Signed) H. J. Van Cleave
Clarence Bonnell,
F. M. Fryxell,
Committee on Resolutions.

JUNIOR ACADEMY REPORTS

JUNIOR ACADEMY *of* SCIENCE SOUTHERN DIVISION, APRIL 11, 1942

On April 11, the various science departments of Southern Illinois Normal University were hosts to the Southern Illinois Junior Academy of Science which is now a division of the State Junior Academy of Science. 200 students from 12 schools of Southern Illinois registered and brought with them 100 different science exhibits.

The features of the day's program were:

1. Exhibits by the high school students.
2. Exhibits and demonstrations by the college science majors.
3. A General Morning program which had as its theme "Science and National Defense."
4. Sectional Meetings in biology and general science, and chemistry.
5. A meeting of high school science teachers in which suggestions to improve next year's meeting were made.

Ribbon awards on which the Junior Academy of Science Seal was mounted were presented to the winners in the various divisions of the high school exhibits. The exhibits were judged on their scientific value, accuracy of information, difficulty, originality, neatness, and effective presentation.

The 1943 meeting will be held on the second Saturday of April. It is hoped that next year even more students will be able to overcome the transportation dfficulties that we are now facing and be able to participate in the 1943 meeting.

The science teachers attending this year unanimously declared their wish that the meeting be held next year and pledged their cooperation in overcoming whatever difficulties that we may be faced with at the time.

I am enclosing the programs for the day, a list of the winners in the high school exhibits division, a list of the exhibits, and the judge's scoring sheet.*

Sincerely,
(Signed) Audry Hill,
General Chairman,
Southern Division.

SCIENCE AIDS SERVICE, 1941-42

During the current academic year *Science Aids Service*, published under the auspices of the Division of University Extension in the University of Illinois and with aid of the Illinois and Indiana Academies of Science for the benefit of science clubs affiliated with the Junior Academy of Science wherever located, has been published in the three issues, representing a total of approximately 14,000 words of information specifically related to the needs of science clubs, science club sponsors, as well as officials who are concerned with the possible values and general welfare of the Junior Academy of Science movement.

The following facts are of interest in connection with the publication:

(1) The Indiana Junior Academy of Science has voluntarily maintained its "Sustaining Membership" for the eighth consecutive year.

(2) The Illinois State Academy of Science with the aid of other state Academies of Science as indicated in the minutes of the Transactions published heretofore has made possible the issuance of *Science Aids Service* and its predecessor for the past nine years. In that time approximately 130,000 words of information designed to aid in the development of the

**Not printed here to save space*

science clubs and the Junior Academy movement have been released in printed form.

As a further aid to science clubs affiliated with the Illinois Junior Academy of Science, the following new duties have been assumed by Science Aids Service as a unit of University Extension:

(1) The loan of any and all nine Science Aids Service kits to affiliated clubs with dues paid for the current academic year. This represents a total retail value of $4.50 per club.

(2) The development of statistical information specifically concerned with the Illinois Junior Academy of Science.

(3) Preparation of radio scripts and articles for periodicals. One article has been prepared for *The Illinois Interscholastic* and another has been accepted for publication in *School Science and Mathematics.*

Other services which have been maintained include:

(1) *Correspondence*
The inclusion of Junior Academy information in letters concerned with Science Aids Service as a unit of the Division of University Extension. Approximately 4000 such letters have been mailed during the academic year.

(2) *Administrative Needs*
Supplies of various needs such as exhibit entry forms, annual programs, special postes for the registration, exhibition and other aspects of local needs.

(3) News-Letter Exchange—as outlined in the Annual Report of 1940-41.

By way of a concluding statement it will be noted that the Illinois Junior Academy, its sponsors and related organizations have had the benefit of three issues of *Science Aids Service* for less than the cost of a single issue of the leaflet. Further that the postage on the 4,000 items mailed for the benefit of the Junior Academy is in excess of the total charge made by Science Aids Service.

(Signed) Louis A. Astell, *Supervisor.*

COMMITTEE ON HIGH SCHOOL SCIENCE AND CLUBS

The committee met in Urbana November 6 at 7:30 p.m. in the Natural History Building at the University of Illinois, Urbana. Present: Allen R. Moore, John C. Ayres, Mary Creager, John C. Chiddix, Rosalie M. Parr, Louis A. Astell, Blanche McAvoy, Lyell J. Thomas, S. Aleta McEvoy, J. W. Neckers, L. W. Miller, O. L. Railsback, H. Waldo Horrabin, C. E. Montgomery. Absent: Dwight L. Barr, Audry Hill, C. W. Whitten, and Dorothy Phipps. The Chairman reported that Louis Astell had accepted the office of Local Chairman for the meeting of May 8. A discussion of plans for the annual meeting followed.

Allen R. Moore suggested that, inasmuch as cups will not be awarded this year, the certificates of award be "dressed up" with seals and ribbons. On motion of Dr. Montgomery the suggestion was adopted.

The Chairman asked for expressions of opinion regarding cooperation between the Illinois Junior Academy of Science and Science Clubs of America. Members of the committee seemed to be in favor of cooperating with a national organization when a suitable and approved organization is set up. Official action was postponed pending the December meeting of A.A.A.S., which Dr. Thomas planned to attend.

The Chairman expressed the hope that every member present would make a special effort to increase the enrollment of schools in the Junior Academy. Mr. Astell promised to circularize the larger high schools of the state. (During the year articles on the Junior Academy by Allen R. Moore, Louis A. Astell, L. J. Thomas and Mary Creager have appeared in *Interscholastic* and *The Living Museum.*)

The participation of college students in a college section received favorable comment, but no action was taken by the group.

Mr. Chiddix, Chairman of Judging, was appointed to investigate some type of rating scheme for making awards, perhaps plan on the order of that used in music contests.

The committee adjourned at 10:30 p.m.

(Signed) Mary Creager,
General Chairman
Allen R. Moore
Ass't. General Chairman

The **annual meeting** of the Junior Academy held in conjunction with that of the Senior Academy at Urbana, May 8-9, was attended by 350 high school students from twenty-one schools. One hundred thirty-seven exhibits were on display and were judged during the meeting. The student president of the Illinois Junior Academy of Science, Jack Frenzen, and students winning outstanding awards in each division were invited to broadcast over Station WILL on May 9, the program being under the direction of Dr. Parr.

At the annual business meeting, the following officers were elected for 1942-43:

President: Robert Rost, Bloomington High School.

First Vice-President: Grover Stevens, J. Sterling Morton H. S.

Second Vice-President: Clifford Hall, J. Sterling Morton H. S.

Secretary: Frederick Wood, Mt. Carmel H. S.

The A.A.A.S. Honorary Members are:

Mary Cecil Craig, Chester High School

Robert Kling, Mt. Carmel H. S.

(Signed) Mary Creager,
General Chairman
Allen R. Moore,
Ass't. General Chairman

HIGH SCHOOL SCIENCE CLUBS AFFILIATED WITH THE ILLINOIS JUNIOR ACADEMY OF SCIENCE

Audubon Club
Bloom High School
Chicago Heights, Illinois
Miss Altha Haviland, Sponsor

Biology Club
Galesburg Senior High School
Galesburg, Illinois
Mrs. Velma L. Whipple, Sponsor

Normal Community H. S. Biology Club
Normal Community High School
Normal, Illinois
Dale DeNeal, Sponsor

Blue Island Biology Club
CommunityHigh School
Blue Island, Illinois
Elizabeth White, Sponsor

Chem Club
Taylorville, Illinois
Forest L. DeWeese, Sponsor

Chemistry Club
Galesburg High School
Galesburg, Illinois
Marvin Humke, Sponsor.

Chem-Mystery Club
Normal Community High School
Normal, Illinois
Mr. J. C. Chiddix, Sponsor

Danville Science Club
High School
Danville, Illinois
C. O. Johnson, Sponsor

East Side Science Club
Senior High School of East St. Louis
East St. Louis, Illinois
J. W. Galbreath, Sponsor

Fenger Science Club
Fenger High School
11220 Wallace Street
Chicago, Illinois
Emil C. Bennett, Sponsor.

The Ferreters Biology Club
High School
Chester, Illinois
Mary Creager, Sponsor

General Science Club
Hitchcock Junior High School
Galesburg, Illinois
Charlotte Wilcox, Sponsor

General Science Club
Ottawa Township High School
Ottawa, Illinois
Mildred Morgan, Sponsor

Lake View Biology Club
4015 N. Ashland Avenue
Chicago, Illinois
J. E. Coe. Sponsor

Lansdowne Science Club
Lansdowne Junior High School
39th Caseyville Avenue
East St. Louis, Illinois
Elsie A. Hoenig, Sponsor

Major Powell Science Club
Normal University High School
Normal, Illinois
Miss Blanche McAvoy, Sponsor

McLeansboro Township High School
Science Club
McLeansboro, Illinois
Miss Edna Woodruff, Sponsor

Morton Biology Club
Morton High School
Cicero, Illinois
Mildred Parizek, Sponsor

Morton Chemistry Club
J. Sterling Morton High School
5910 W. 26th Street
Cicero, Illinois
G. S. Porter, Sponsor

Morton Physics Club
Morton High School
Cicero, Illinois
A. E. Smith, Sponsor

Morton Weather Club
Morton High School
Cicero, Illinois
Allen R. Moore, Sponsor

Mt. Carmel Science Club
Mt. Carmel High School
Mt. Carmel, Illinois
B. D. Arrick, Sponsor

Normal Science Club
Illinois State Normal University
Normal, Illinois
George A. Soper, Secy.-Treas.

St. Xavier Science Club
4900 Cottage Grove
Chicago, Illinois
Fita Marie Johnson, Treas.

Vocational Science Club
Granite City Community High School
Granite City, Illinois
Miss Mable Spencer, Sponsor.

Ready Kilowatt
Galesburg High School
Galesburg, Illinois
John Aitchison, Sponsor.

Bloomington H. S. Geology Club
Bloomington High School
Bloomington, Illinois
H. L. Adams, Sponsor.

Ferreters General Science Club
Chester High School
Chester, Illinois
Mary Creager, Sponsor.

Galatia Science Club
Galatia Community High School
Galatia, Illinois
Eldon Walter, Sponsor.

Geomites
Joliet Township High School
Joliet, Illinois
M. E. Leatsler. Sponsor.

Herrin Biology Club
Herrin High School
Herrin, Illinois
Robert L. Smith, Sponsor.

Maine Science Club
Maine Township High School
Park Ridge, Illinois
Audrey Mount, Secy.

Physicon Club
Champaign Senior High School
Champaign, Illinois
Nellie Bates, Sponsor.

Robinson Science Club
Robinson Township High School
Robinson, Illinois
P. K. Houdek, Sponsor.

Science Club
Rantoul Township High School
Rantoul, Illinois
H. P. Leighly, Sponsor.

Shelbyville Science Club
Shelbyville High School
Shelbyville, Illinois
William Schwab, Jr., Sponsor.

University High School Science Club
Southern Illinois Normal University
Carbondale, Illinois
Audry Hill, Sponsor.

Woodruff Science Club
Woodruff High School
Peoria, Illinois
V. C. Shepard, Sponsor.

Zoo Club
E. Rockford High School
Rockford, Illinois.

RESULTS OF SCIENCE EXHIBITS

BIOLOGY:

Individual Posters—

1st—Nutrition, Naomi Kuhner, Herrin.
2nd—Imitations, Hazel Denny, Chester.
3rd—Spatter Prints of Leaves, Hazel Denny, Chester.

Group Posters—

1st—Immunization Record of Our School, Jean Ervin, Jean Jany, Chester.
2nd—Chemical Analysis of Man, Betty Godair, Gene Shelton, Jim Wright, Grand Tower.

Individual Notebooks—

1st—Photomicrographs, Gilbert Church, Anna-Jonesboro.
2nd—Dorris Stupplefield, Herrin.
3rd—Marjorie Rolando, Herrin.

Group Projects—

1st—Insect Collection, Carl McVoy, Wilma Rogers, Dorothy Rendloman, Herrin.
2nd—Models of Developmeut of Frog Egg, Gene Shelton, Mellio Todd, Betty Godair, Grand Tower.
3rd—Process of photomicrography, Vern Echols, Philip Ervin, Galatia.

Individual Projects—

1st—Skull collection, Evis Ramsey, Herrin.
2nd—Embryological Development of Chick, Joe Hauser, Grand Tower.
3rd—Heredity Rat Project, Naomi Kuhner, Herrin.
3rd—Clay Model of Head, Gail Willbrand, Chester.

GENERAL SCIENCE:

Individual Posters—

1st—State Preservations, Freddie Vaughn, Chester.
2nd—Optical Illusions, Tommy Williams, Galatia.

Group Posters—

1st—Malaria, Chester.

Notebooks—

1st—Mildred Easterly, Cheser

Individual Projects—

1st—Military Models, Richard Vegler, University High.
2nd—Medicines and Chemicals that come from Plants, Walter Michaelis, Chester.
3rd—Model of Coalmine, Micky Jackson, Chesrer.

Group Projects—

1st—Rope Making Machine, Eugene Tato, Joe Massey, James Gollier, Clarence Choate, Galatia.
2nd—Collection of Rocks and Minerals, Jack McGuire, Bob Earlenbough, Chester.
3rd—Model Garden, Galatia.

PHYSICS:

1st—Electric Motor, Herbert Odle, Galatia.

2nd—Model of Telephone, Herbert Odle, Bryce Tato, Galatia.
3rd—Conductivity of Solutions, Wright Cotter, Galatia.

JUNIOR ACADEMY WINNERS *of* AWARDS OUTSTANDING EXHIBITS

These won special recognition by receiving Senior Academy Certificates of Awards:

Biology—Climatic Life Zones of N. Central Arizona.

Kenneth Gutschick, Morton High School, Cicero.

Chemistry—Some of the Important Products of Corn.

William Woura and Arthur Skarda, Morton High School, Cicero.

Geology—Grand Canyon Cross-section and Rocks.

Kenneth Gutschick, Morton High School, Cicero.

Junior High School—Model Town.

Marvin Fuller, Lynn Wiese, Edward Wichersham, Marcia Franklin, Bob Crawford, Lee Overdorf, Jim Craig, Jack Wilds, Tom Bullis, Bob Sandburg, and George Shirek—Hitchcock, Jr. H. S., Galesburg.

Newsletter—The Zoo.

Chris Garmenger, Editor—East Rockford High School, Rockford.

Photography—Kodachrome Slides.

Mary Cecil Craig, Chester High School, Chester.

Physics—The Transmission of Sound Over a Light Beam.

J. Frederick Wood, Mt. Carmel High School, Mt. Carmel.

EXHIBIT WINNERS

The Chemistry Club
Galesburg High School, Galesburg
Mr. Marvin Jumke, Sponsor.

Chemistry
Group Commercial Product, The Making of Rayon
1st—Alan McClelland and Gordon Robertson.
Individual Project, A Dry Cell
2nd—Edgar Luttnell

Chemistry Club
J. Sterling Morton H. S., Cicero
W. L. Muehl, Sponsor.

Chemistry—
Individual Notebook, Fabrics and Their Properties
1st—Alberta Luebbe.
Group Vitamins, Vitamins
1st—Elinore Zusman and Dorothy Vodak.
Group Model, Still—Sulphuric Acid by Contact Method
1st—Ray Novy, Russell and Richard Nesladek.
Individual Notebook, Removing Stains
1st—Lois Voss.
Individual Model, Moving, Brush, Electroplates
1st—Robert Feltgen.
Group Project, H N O_3 Arc Process
1st—Robert Gaynar and Leo Temsovick.
Newsletter, *Phe Chem Ray*
1st—Barbara Hopp, Editor.
Individual Poster, Sulphur
2nd—William Seeman.
Individual Commercial Product, Distillation of Gasoline
2nd—Dick Kacena.
Individual Project, Soil Analysis of Cook County
1st—Otto Turnovsky, Jr.
Individual Project, Chemical Warfare
2nd—Jean Kahoun.

Major Powell Science Club—
University H. S., Normal
Blanche McAvoy, Sponsor.

Chemistry—
Individual Poster, Anti-Freezes
1st—John Douglas.

Biology—
Individual Project, Mounted Animals (Taxidermy)
1st—Wilma Amacher.

Chem-Mystery Club
Normal Community H. S., Normal
J. C. Chiddix, Sponsor.

Chemistry—
Individual Project, Testing Vitamins
1st—Elmer Smith.
Group Poster, Vitamins
1st—Lillian Morgan and Frank Netterville.
Science Newsletter, Chemistry Helps Defense
1st—Marian Gates, Charlotte Norris and Doris Collins.
Individual Notebook, Paper
1st—Janet Taylor.
Individual Notebook, Rubber, a Vital Necessity
2nd—Margaret Hinshaw.
Individual Poster, Synthetic Rubber
2nd—Frank Netterville.
Individual Project, Testing Oil.
2nd—Roy Barclay.

Science Club
Rantoul Township High School
H. P. Leighly, Sponsor.

Science Club
Group Project, Migration of Ions
2nd—Margaret Francisco and Jeanne Fitten.
Individual Project, Equillibrum of NO_2

3rd—Henry Croutti.
Individual Project, Charles Laws' Apparatus
3rd—C. Ayres.

Zoo Club
East Rockford H. S., Rockford
S. Elata McEvoy, Sponsor.

Photography—
Individual Collection, Photographs of Yosemite
1st—Kenneth Anderson.

Biology—
Newsletter, *The Zoo*
1st—Chris Garmenger, Editor

Woodruff Science Club
Peoria Woodruff H. S., Peoria
V. C. Sheppard, Sponsor.

Geology—
Individuals Project, Flurescent Minerals
2nd—Edward Zeller.

Bloomington H. S. Geology Club
Bloomington H. S., Bloomington
A. L. Adams, Sponsor.

Geology—
Individual Project, Results of Coal Recovery
1st—William Baumgart.
Individual Project, General Notes on Geology
2nd—Bob Solomon.
Individual Project, Electric Weather Vein
2nd—Happy Holton.
Individual Project, Crystal Structure of Mineral.
1st—Dick Rost.
Group Project. Minerals for National Defense
2nd—Bloomington H. S. Geology Club.

Blue Mound Biology Club
Community H. S., Blue Island
Elizabeth White, Sponsor.

Biology—
Individual Project, Automobile Theft Alarm
2nd—Irvin Tolle.
Group Project, Code Practice Oscillator
3rd—Richard Hausel and Hendrik Van Vliet.
Individual Project, Steam Engine
3rd—Ray D. Camexan.
Group Project, Transmission by Modulated Light Beam
2nd—Hendrik Van Valiet and Richard Housel.

The Ferreters
Chester High School, Chester
Mary Creager, Sponsor.

Biology—
Individual Model, Model of Head
1st—Gail Willbrand.
Individual Collection, Bird Eggs
1st—Joan Siegfried
Individual Poster, Inheritance of Finger Lengths
3rd—Constance Parrish.
Group Project, Animal Blood Slides
2nd—Glodine Welge, Dorothy De Rousse, Doris Hall, Dick Davis and Willard Davidson.
Science Notebook, Snakes of Randolph County.
3rd—Sybil Coffey.
Group Poster, Blood Typing
2nd—Lloyd Gibson, Jean Ervin and Jeanne Jany.
Group Model, Poisonous Snake's Head
2nd—Opal Choate and Dick Davis.

Chemistry—
Individual Project, Chemicals in Removing Stains
2nd—Sybil Coffey.

Photography—
Individual Project, Photomicrographs
2nd—Mary Cecil Craig.
Photomicrographs, Kodachrome Microphotographs
1st—Mary Cecil Craig.

Geology—
Group Project, Mounts of Prehistoric Men
2nd—Leo Ehlers and Elinor Auld.
Individual Project, Temperature Graph
2nd—Vernice Brelig.
Group Project, Rocks and Minerals.
2nd—Margaret Welton and Beaulah Grah.

General Science—
Individual Project, Plant Products
2nd—Walter Michaelis.
Group Project, Malaria
2nd—Mildred Easterly, Jene Best and Freddie Vaughn.
Group Poster, Germs, Our Treacherous Foes
2nd—Norma Hamilton and Ruth Wright.
Individual Collection, Shells
2nd—Kenneth Huffmaster.

Physics Club
J. Sterling Morton H. S., Cicero
A. E. Smith, Sponsor.

Physics—
Individual Project, Grinding Reflecting Telescope.
1st—Joseph Holly.
Group Project, Resonance Transformer
1st—Cliff Hall Jack Frenzen.
Group Project, Fluorescence and Phosphorescence
1st—Robert Lebdjcka and Robert James Havlik.
Group Project, Tube Demonstrator.
1st—Steve Erst and Richard Schimpf.
Individua Project, Vibrograph
1st—Frank Holecek.
Individual Project, Talking Over a Beam of Light
2nd—Dan Swartwant.
Individual Project, Cottrell Precipitation
2nd—Owen Sladek.
Group Project, Newton's Law of Gravity
2nd—Grover Stephens and Robert Boerke
Individual Commercial Product, P. A. System and Record Player
2nd—Anton Horn.

Modern Physics, The Principle Behind the Electron Microscope
2nd—Harold Murry.

The Biology Club
J. Sterling Morton H. S., Cicero
M. Parzek, Sponsor.

Biology—
Individual Project, Victory Garden Poster
1st—Dorothy Long.
Group Project, Plaque of a Flower
3rd—June Jorm and Shirley Klasek.
Group Project, Nutrition Experiment
1st—Nellie Birkjoff, Gladys Kawczynski, June Keine, Helen Coran and Elaine Voculik.
Individual Notebook, Soils and Gardening
1st—Camillie Placzek.
Group Collection, Spatter Prints
2nd—Elaine Qila, Dorthea and Muriel Matson.
Individual Collection, Collection of Slides of Molds and Bacteria
1st—Coral Kudrna.
Individual Project, Climatic Zones of N. Central Arizona.
1st—Kenneth Gutschick.

General Science Club
Hitchcock Jr H. S., Galesburg
Charlotte Wilcox, Sponsor.

Biology—
Individual Commercial Project, Gum
2nd—Bob Simmons.
Individual Collection, Leaves
2nd—Helei Bringlesar.
Group Radio Notebook, Radio
1st—Bill Cheesman and Bill Barnes.
Individual Notebook, Food
1st—Gayle Bristol.
Group Poster, Have You a Record?
2nd—Dan Lersh, Betty Hanson, Lee Furrow, Kenneth Roberson, and Barbara Lanerman.
Individual Radio Notebook, Amateur Radio
1st—Ted Beauchamp.
Group Notebook, This Is War
1st—Edward Wickersham and Marian Fuller.
Group Project, White Rat Experiment
1st—Lee Furrow, Dick Walton and Don Rodenhansen.

Photography—
Group Commercial Project, Commercial Photography
1st—Jim Hoopes, Jack Zeldes and LeRoy Grabill.
Individual Project, Enlarger
2nd—Jan Bengstan.

Geology—
Individual Model, Oil Refining
1st—Edward Wickersham.
Individual Poster, Explosive Volcano
2nd—Francis Alice Firth.
Group Collection, Rocks
1st—Dean Anderson, Jack Zeldes and LeRoy Grabill.

Weather and Geology Club
J. Sterling Morton H. S., Cicero
A. R. Moore, Sponsor.
Individual Notebook, Grand Canyon Notebook
1st—Kenneth Gutschick.
Group Project, Grand Canyon Model
1st—Kenneth Gutschick and Oris Holt.
Individual Project, Rat Feeding Experiment
1st—Jeanne Pahlke.
Individual Project, Wood Poster
2nd—Barbra Searle.
Individual Notebook, Notebook on Gardening
1st—Thelma Parenti.
Individual Collection, Wildflowers
1st—Eugene Westfall.

General Science Club
Ottawa High School, Ottawa
Mildred Morgan, Sponsor.

Physics—
Individual Project, Heat and Light Arc Furnace
2nd—Bill Knoll.

Geology—
Individual Model, Side View Oil Well
2nd—Barbra Dunavan.
Individual Model, Model Coal Mine.
1st—Roberta Gurney.
Individual Project, Umbrella Planatarium
2nd—Marcia Crawford

Normal Community Biology Club
Normal Community H. S., Normal
Dale DeNeal, Sponsor.

Biology—
Individual Poster, Vitamins for Victory
3rd—Marietta McArthy.
Individual Project, Structures of the Human Body
3rd—Mary Caldwell.
Group Project, *Shells*
1st—Eileen Garvey and Ruth Baker.
Individual Project, *The Human Body*
2nd—Helei Booziotes.
Individual Collection, Shells and Indian Relics.
1st—Bob Halbert.

The Biology Club
Herrin High School, Herrin.
Robert L. Smith, Sponsor.

Biology—
Individual Project, Biology Laboratory Notebook
1st—Margie Rolands.
Individual Notebook, Biology Laboratory Notebook
1st—Doris Stubbefield.
Individual Collection, *Shells*
1st—Margie Rolands.
Individual Project, *Skulls*
1st—Elves Ramsey.
Group Collection, *Insects*
2nd—Carl McVey, Wilma Rogers, and Dorothy Rendleman.
Individual Poster, Effects of Diet on Health as Shown by Hooded Rat Experiments.

2nd—Naomi Kuchner.

Galatia Science Club
Galatia Community H. S., Galatia
Eldon Walter, Sponsor.

Biology—
Individual Model, Adaptation of Birds' Beaks
1st—Emil Sulton.
Individual Poster, Snake Superstitions
1st—Louie Kent.
Individual Project, Fish Questionnaire
2nd—Louie Kent.
Individual Poster, Optical Illusions
3rd—Thomas Williams.

General Science—
Group Project, Rope Making Machine
2nd—Eugene Tata, Joe Massey and Thomas Williams.

Physics—
Individual Model, Electric Motor Showing Amperage.
3rd—Joe Massey.
Group Model, Telephone
2nd—Eugene Tate, Joe Massey, Thomas Williams.
Individual Project, Conductivity of Liquids
3rd—Eugene Tata.
Group Project, Modern Physics, Opaque Projection
2nd—Emil Sutton and Louie Kent.

Photography—
Individual Project, Chemical Stages in the making of Photographs
2nd—Emil Sutton.
Group Project, Process of Making Microphotographs
2nd—Emil Sutton and Louie Kent.

Biology Club
Galesburg High School, Galesburg
Mrs. Velma Whipple, Sponsor.

Biology—
Individual Project, Lantern Slides
1st—Wayne Swallows.
Individual Project, Experiments with Fertilizers
3rd—Farrey B. Clary.
Group Project, Victory Garden
2nd—Helen Borrow and Bettie Johnson.
Group Project, Experiments with Plants
2nd—Betty Harler and Edna Mergenthaler.

Geology—
Individual Project, Artificial Formation of Stalagmites.
3rd—Clark Highlander.
Individual Poster, Processing of Oil
3rd—Bill Graham.

The Biology Club
Park Ridge H. S., Des Plaines—Park Ridge
Mrs. Leila H. Baas, Sponsor.

Biology—
Individual Project, Wood Carving
2nd—Laverne Thomas.
Individual Model, Mitosis and Meosis
1st—Thomas Cunningham, Jr.
Individual Project, Effect of Solar Spectrum on Plants
3rd—Fred Everhard.
Individual Collection, Shells
2nd—Elinor Banka.
Group Project, Chemical Man.
1st—Fred Everhard, Marilyn Ellinger, Audry Mount, Laverne Thomas and Thomas Cunningham, Jr.
Newsletter, Biology
2nd—Marge Grieve and Perky Gates.

Ready Kilowatt
Galesburg H. S., Galesburg
John A. Aitchison, Sponsor.

Physics—
Individual Project,
2nd—Richard Pierson.
Individual Project, Reflection of Light
3rd—Edgar Luttrell.

TRANSACTIONS

OF THE

ILLINOIS STATE ACADEMY OF SCIENCE

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1941-1942

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STATE OF ILLINOIS

DWIGHT H. GREEN, Governor

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VOLUME 35 SEPTEMBER, 1942 NUMBER 1

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Urbana, Illinois, May, 1942

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EDITED BY GRACE NEEDHAM OLIVER

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ILLINOIS STATE MUSEUM DIVISION, CENTENNIAL BUILDING

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FRANK G. THOMPSON, *Director*

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ANNOUNCEMENTS

Attention is directed to the fact that the Committee on Research Grants of the Illinois State Academy of Science has at its disposal a small sum of money to be disbursed in support of worthy research projects. Applications for grants will be accepted up to and including March 31, 1943. It is customary to give preference to scientists connected with the smaller institutions of the state.

Requests for grants should be accompanied by a brief statement of the training and experience of the applicant, the purpose of the investigation, and the estimated cost. Previous publications should be listed. At least two letters of recommendation should be transmitted directly by their authors. Correspondence may be addressed to L. H. Tiffany, Northwestern University, Evanston, Illinois.

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1943 MEETING: JACKSONVILLE, MAY 7-8

THE CONSERVATION RESEARCH PROGRAM OF THE ILLINOIS NATURAL HISTORY SURVEY

T. H. Frison*

APPLIED programs in the field of biological science are seldom, if ever, developed without the aid of years of patient, so-called unapplied, researches. If we assume that the present applied renewable natural resources program of the Illinois Natural History Survey is a feature of its work during the past decade, then we must acknowledge as the foundation of this newer program a previous half-century of basic, varied and monumental biological research by S. A. Forbes, former Chief of the Survey and past president of this Academy of Science, and his associates.

The early program of the Natural History Survey and its predecessors tends to separate into two phases of activity. One of these may best be characterized as a faunistic and floristic survey of Illinois, and resulted in such comprehensive reports as *The Ornithology of Illinois* by Robert Ridgway, and *The Fishes of Illinois* by S. A. Forbes and R. E. Richardson. The less inclusive reports are too numerous to mention specifically. They are varied in content, ranging in scope from broad biological surveys of certain local areas, both land and water, to detailed studies of species. This basic survey of the flora and fauna of the state is still in process of completion, but the emphasis rests today on groups of smaller organisms about which less is known.

Another phase of this earlier program of the Natural History Survey may be truly considered as economic biology, and the threshold of what now is referred to as wildlife resources management. I refer here primarily to a series of papers on the food of birds and fishes, and on the numbers and distribution of birds in various sections of the state. This early work on the food of birds, by S. A. Forbes, has been referred to by Weed and Dearborn (1903) in their book entitled *Birds in Their Relations to Man* as furnishing "the basis for the modern development of economic ornithology," and by McAtee (1917) who states in a more recent publication that this work, together with the work of another early ornithologist, is the foundation "of the scientific method of studying the economic value of birds." The Survey bulletins of Forbes and Gross (1921-1923) are representative of the present census technique of today's game management studies. A series of reports on forestry in Illinois from 1910 to 1926 certainly paved the way to a great extent for the introduction of public ownership and management of forested lands in Illinois and state forestry agencies now in existence.

Beginning in about 1934, in addition to a continuation of efforts to complete basic surveys of the flora and fauna, special emphasis began to be placed, in the sections of the Survey dealing with fish, game and forests, upon the management of these resources. Management, whether of fish, game, fur bearers, or forests, is the act of making such resources produce sustained crops. These crops may be for recreational uses, a combination of recreational and utilitarian uses, or complete utilitarian uses. When we arrive at the point of complete utilitarian uses of our wildlife resources, we have entered the field of animal husbandry.

Although certain aspects of wildlife management have been practiced in Eurasia for a long time, the altering in America of environments or ranges according to biological principles, for greater productivity of desired renewable natural resources, is comparatively recent. This is understandable on the basis that our culture is young and we are close to generations whose almost total existence was taken from the woods, waters and soils of our domain. Even today, in the midst of a great industrial development, as individuals we cling to a heritage of public rights in renewable natural resources, particularly forests, fish and game, and through intimate personal con-

* Chief, Illinois Natural History Survey, Urbana, Illinois, Retiring President of the Academy.

tact with these resources preserve a culture which is peculiarly American.

In a paper presented in the General Session of this Academy in 1934, I gave a six-point summary of my ideas held at that time for a land utilization program in Illinois for forestry, wildlife and recreation. It is cheering to note that there have been worthwhile accomplishments under each of these points, including the establishment of a National Forest in southern Illinois, additional state and county forests, expansion of the state park system, establishment of upland game and migratory waterfowl sanctuaries, and the ending of large-scale promotional and exploitational schemes detrimental to renewable natural resources. These developments during the past decade have been the result of the activities of many agencies and individuals, but I am happy to state that, within the state, the Natural History Survey has played an important, often pivotal, part in each of them.

As previously mentioned, special emphasis upon the management of the state's renewable natural resources by the Natural History Survey dates from about 1934, the year in which the first game technician was appointed to the staff. Although an aquatic biology section was functioning long prior to this date, its program, too, became subject to reorientation along management principles about this same time. In 1935 a Mid-Western Wildlife Conference was organized at Urbana, sponsored by the Survey, to serve as a clinic and clearing house for the views and conclusions regarding wildlife resources investigations in the central states region.

The next big step in organization for renewable natural resources research came in 1937, when appropriations were obtained to increase the staff, construct field laboratories, and establish experimental areas. This program was again augmented in 1938, in cooperation with the Illinois State Department of Conservation and the U. S. Fish and Wildlife Service under the Federal Aid in Wildlife Restoration Act.

The preceding statements about past accomplishments and more recent advancements in the organization of the Natural History Survey for researches in the field of the renewable natural resources of Illinois have, perhaps, brought to mind questions regarding the general objectives of such a revised program and also regarding recent results from these investigations.

One of the phases of any investigation of valuable renewable natural resources is the establishment of accurate and impartial data regarding each resource as a guide to insure its preservation or its management on a maximum or sustained yield basis. Seldom do we find the simplest of the required basic data available or in such form that they can be utilized without reworking. When dealing with wildlife management problems, we must have reliable information concerning a large number of matters. For instance, in the case of each wildlife species involved, we need a close approximation of its numerical abundance, its distributional pattern within the state, what constitutes its most favorable natural breeding territory; and we need to know if there are measurable swings over a period of years from low to high populations and back again. We need to know about the breeding seasons of the species involved; and much other biological information. It must be understood that for best management results each species of fish, fur bearer, migratory waterfowl, upland game bird, or other renewable natural resource unit, must be studied separately in respect to such matters, and then again from the standpoint of its relation to its total environment.

Although the sum total of these investigations is a big and long-time order for any agency, many of the techniques necessary to secure the data, as well as much of the desired information and needed basic generalizations, are being obtained at a comparatively rapid rate. Thus it happens that even in the midst of a youthful program and the establishment of necessary preliminary basic data, the Survey is now actively pursuing some phases of the ultimate objectives of a state-supported renewable resources study; namely, the development of practical methods and information for resources preservation and utilization for the benefit of the general public. In support of this statement, it is possible to cite many examples where the results obtained to date are accomplishing their purposes. I have time to mention only a few such instances, selected to show the variety of

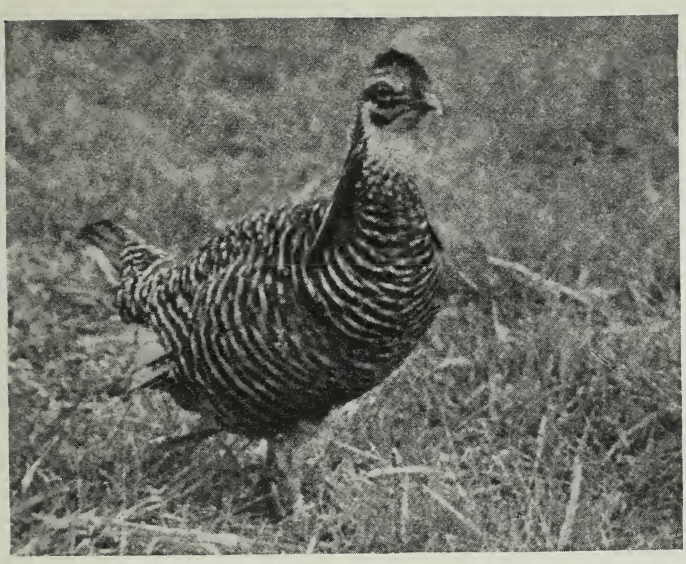


Fig. 1.—Male of the prairie chicken, once an abundant and valuable bird in Illinois, now in need of protection and further study.

ways in which scientifically acquired renewable natural resources information can be utilized to attain desirable goals.

Studies of the prairie chicken reveal that efforts directed toward the management of this splendid bird, so familiar to the early settlers in Illinois, must of necessity focus almost entirely around the preservation of a small number of remnant flocks, and any proposals for the removal of this game bird from the list of protected birds under present agricultural conditions should be opposed. Furthermore, favorable nesting territory is such that any grandiose schemes for the propagation and release of the prairie chicken in numbers throughout the state, with the hope of permanently supplementing game birds for hunting purposes, is foredoomed to dismal failure. Our studies of prairie chickens, therefore, may already be confidently used to prevent undesirable game law legislation and unwise expenditures of conservation monies.

Information in hand concerning rabbits, which, by the way, are an important item in the meat diet of many families in certain parts of this state, gives us an altogether different type of conclusion. In the management of this resource we can recommend a limited amount of utilization along with preservation. We now know that great fluctuations exist in the abundance of this animal from year to year, and that this rise and fall in numbers, over a period of years, is a normal expectation. It is sound management, therefore, to recognize that the cropping of this resource — an estimated 3,000,000 pounds went to market annually preceding 1937—could be considerably increased, at least in certain peak years, without permanent impairment of our necessary basic breeding stock.

For some years there has been a lively controversy in this state regarding the soundness of the time of the open season for the hunting of squirrels; another resource which, without attracting much public attention, makes a considerable contribution to the meat diet of many families, particularly in the central and southern parts of this state. The settlement of this argument depends upon the definite establishment of information pertaining to the time and duration of the breeding season in different game zones. It would seem to most people, because of the commonness of squirrels, that trustworthy information about breeding seasons would be already available, but this was not so when Natural History Survey studies, made in cooperation with the State Department of Conservation and the U. S. Fish and Wildlife Service, were begun. Investigations are now in course

Fig. 2.—Through the banding of waterfowl, Illinois Natural History Survey wildlife technicians gather data on migration habits, travel lanes, kill and survival ratio, and other data that will lead to recommendations designed to prevent depletion of these valuable birds that suffered following the first World War.

of completion which will give authoritative answers to the questions involved, and thus serve to influence game law legislation which will insure proper hunting seasons, and thereby the intelligent cropping of this resource.

At this time, a detailed report on the fur resources of Illinois is in preparation. The fur bearers are now known to contribute about $1,000,000 annually to the income of Illinois families, chiefly in the low income group where it is most

Fig. 3.—The place of native waterfowl food plants in relation to the millions of waterfowl that use the Mississippi-Illinois flyway is being studied by the Illinois Natural History Survey. Shown here is a bed of rice cut-grass, one of the best of the native plants.

Fig. 4.—For effective management of small artificial lakes, techniques must first be developed in experimental bodies of water. The recording thermograph shown here is one of the instruments by which Illinois Natural History Survey technicians study the influence of temperature on fish production.

needed. If anything is ever to be done toward a managed increase of this important resource, this report will be basic to that undertaking.

The data obtained in the course of the Survey's fisheries investigations have been quite revolutionary and counter to many generally held ideas concerning ways to improve fishing. This phase of research management investigations is gradually approaching the techniques of a more mature animal husbandry program.

Time will not permit me to go into further detail concerning the many and varied projects in the renewable natural resources field now under investigation by the Natural History Survey. The re-

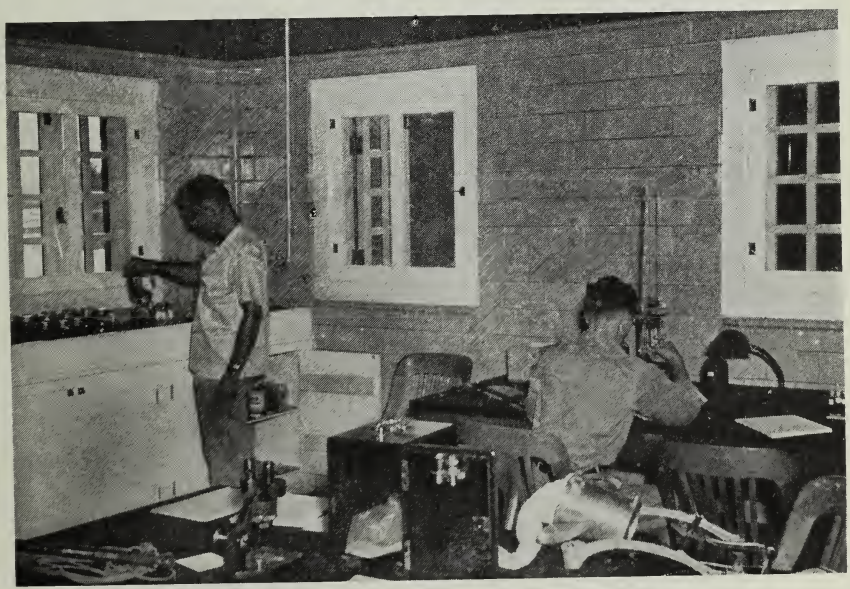


Fig. 5.—Two fish technicians at work in the new Illinois Natural History Survey laboratory at Ridge Lake, near Charleston. Oxygen content of water and other scientific data are determined as part of the experimental program that will lead to recommendations for improved growth rates of fish in small artificial lakes.

sults from this work are rapidly accumulating, and I am certain that they are destined to influence profoundly the preservation and utilization of the state's renewable resources; in fact, this scientific basis for state action is already taking place.

In an earlier part of this paper, while broadly reviewing the general objectives of the Survey's present applied program, I called attention to the youthfulness of these investigations. This is an admission that in many instances we are involved in a long-time program, and that from many problems now under investigation no conclusions can be drawn for some years to come. Cyclic fluctuations cannot be determined by a year or two of observations, nor can game management policies for our most intensively farmed areas be promulgated on the basis of study areas two or three years old, with plantings which require some years for mature growth. Determinations of balanced fish combinations to be used in stocking new reservoirs and the best methods of cropping must be tried in many localities and under varying conditions. All such programs demand a reasonable amount of continuity and time.

Now, just when we are virtually getting started on a new program of practical management studies of resources, the greatest war of all time is thrust upon us. If it took a major depression to awaken Americans to the realization that renewable natural resources are important to our well-being, and that we must initiate scientifically planned researches to insure their continued existence and use, I feel safe in asserting that this war will drive home to all the absolute necessity of our varied resources to our standards and ways of living. Some resources, to be sure, are more important, at least for the moment, than others, but it is all of them

Fig. 6.—Properly managed artificial lakes in Illinois can produce good catches of bass and other desirable fish, as shown by this scene at Lake Glendale, in the Shawnee National Forest.

together, each in its place, which have made the United States the envy of the rest of the world, and the nation which we cherish today.

Concessions to the war effort must, and will, be made by all individuals and every normal program. Already, the Survey is reorienting its program to aid the war effort as best it can. The renewable resources of both state and nation will contribute their share in the support of our cause in the form of food, clothing, and in many other forms.

As an example of this support, let me cite the case of one renewable natural resource scarcely mentioned heretofore in this address; namely, forest products. It has been stated by Ovid Butler, of the American Forestry Association, that each of our forests must give at least five trees to equip and maintain each man in our armed forces. These trees are used to give him his living quarters and training camp, the wooden crating necessary to ship him food, clothing, tanks and guns, for the making of high explosives, bombers and battleships; in fact, virtually every piece of equipment necessary to wage modern war.

While we must open our resources to the nation in its time of greatest need, we must be on guard, also, to prevent

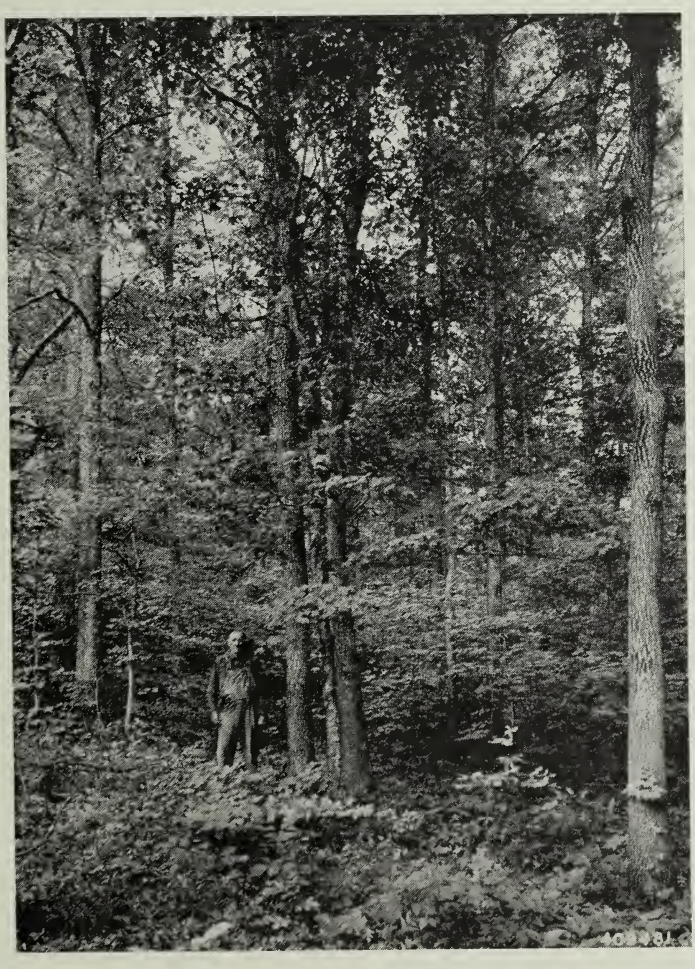


Fig. 7.—Stand of white oak timber in the Shawnee National Forest, southern Illinois. Publicly and privately owned forestry resources of the state can contribute materially to the war effort, but exploitation that is unnecessary and permanently injurious should be studiously avoided.

exploitation that is unnecessary and permanently injurious. Many proposals are apt to be put forward under the guise of the national war effort which are valueless, and they must be rigorously opposed by technical agencies.

Although I will not have time to elaborate upon this subject, the recreational uses of wildlife resources will contribute greatly during the coming months to make our war efforts successful. The benefits from outdoor recreation are exceedingly difficult to evaluate in dollars and cents, but, nevertheless, we know that mental and physical health is expensive to rebuild and that some recreation is essential.

I cannot resist closing this address with a prophecy; to wit, that after the war renewable natural resources programs will be sponsored by the state and nation more than ever before. These programs to be worth anything should have the guidance of experienced scientific organizations. Such agencies cannot be assembled over night. So, let us hope that while giving everything necessary to win the war, we will have the vision to preserve the essentials in scientific endeavors as the spring board for our country's rejuvenescence after the war.

(This talk was followed by a colored motion picture showing activities of the Illinois Natural History Survey relating to research on wildlife resources.)

THE BETATRON*

D. W. Kerst, University of Illinois, Urbana, Illinois

FROM THE experiments of the past eleven years and from still earlier experiments we have learned a great deal about the phenomena of nuclear disintegration, especially about artificially produced disintegration, which follows as a result of nuclear particles being forced together so that some degree of interpenetration occurs. Since the nuclei of atoms are positively charged, the great repulsive forces arising from a very close approach must be overcome before there will be penetration. One cannot take a hold of nuclear particles or push directly on individual particles; so the method which has been used with such great success is that of impact. Charged nuclei, or positive ions, of one variety are accelerated in a high voltage vacuum tube in which the electrodes are arranged to force them toward a target of a substance containing the other nuclear particles to be bombarded. It is common in these artificial disintegration experiments to reach forces as great as 20 pounds weight between individual nuclei during the impact process. This force is far out of the range of those which occur in the most intense compression that can be produced by other means.

It is only in the case of the neutron, the uncharged nuclear particle, having approximately the same mass as the proton, that penetration into other nuclei occurs easily, and this is because the lack of charge on the neutron makes electrical repulsion impossible.

One other reason for giving one of the nuclear particles a high energy is that when the two nuclei collide certain reactions will not occur unless the energy brought to the collision by the high speed particle is sufficient to supply the energy required for this reaction. It is mainly for this reason that if disintegrations are to be produced by electrons or by the x-rays which they produce, the electrons must have very high energy.

The nuclear physicists who have become high voltage experts in order to do these disintegration experiments make use of several varieties of high voltage apparatus to impart large energies to small particles. Except for disintegrations produced by particles from naturally radioactive substances, the equipment usually used for producing high speed particles has been either a linear accelerator or a cyclotron. In the linear accelerator the charged particles are pushed from electrode to electrode down the axis of a long vacuum tube. The electrodes are generally hollow cylinders connected to successively higher voltages. The voltage is supplied either by a large transformer-rectifier combination or by the Van de Graaff type of electrostatic generator which charges a high voltage electrode by means of long moving belts. One end of the accelerating tube is connected to this high voltage electrode, and the other end is usually at ground potential. This accelerator has been developed to the extent where it produces about 4.5 million volts when confined in a tank no larger than 5.5 feet in diameter and 22 feet long, provided the high air pressure of about 100 pounds per square inch is used for insulation of the high voltage terminal. This type of accelerator has been used to some extent for the study of nuclear reactions produced by electrons and x-rays having energies up to three million electron volts, but most of the work of the electrostatic accelerator has been with positive ions. There is a large number of nuclear reactions called photodisintegrations which can occur by electron or x-ray bombardment, but these require on an average six to eight million electron volts of energy before the reaction can proceed. For these experiments energies greater than those obtained by the electrostatic generator are necessary.

In the cyclotron the positive ions do not follow a linear path. Rather they are bent by a magnetic field into a spiral path, and they are accelerated back and

* Invited paper presented before the Physics Section meeting at Urbana, Ill., May 8, 1942.

forth between two dee shaped hollow metal electrodes. The reason this can be done is that when a group of positive ions are well shielded within one of the dees this electrode reverses potential with the other electrode; and by the time the positive ions are in position to pass to the other dee, the potential is such that they are forced forward to a greater speed. This requires that the dees be connected to a high voltage high frequency oscillating circuit. The final energy which the positive ions achieve is the product of the number of transits from dee to dee and the voltage between dees. With this apparatus deuterons have been accelerated to 16.5 million electron volts, far more than the voltage which can at present be produced on a single insulated electrode such as that used on the electrostatic machine.

However, the cyclotron cannot apply its great voltage to electrons. The reason for this lies in the onset of relativistic behavior of the electron at very low energies. Particles behave in a distinctly relativistic manner when their kinetic energy approaches or exceeds the energy equivalent of their rest mass. For example, the rest mass of a proton is equivalent to about one billion electron volts. Protons of this energy would show pronounced relativistic behavior; however, the electron with a rest mass equivalent to only .5 of a million electron volts will behave relativistically at this low voltage. At .5 of a million electron volts the electron is traveling at approximately .9 of its speed limit, the velocity of light. Since one of the requirements in the operation of a cyclotron is that the accelerated particle increases its speed in proportion to the square root of the number of revolutions, it is impossible for an electron near its speed limit to fulfill this condition. Consequently, a cyclotron could only be used for electrons at voltages well below half a million volts.

Fortunately the betatron operates equally well at classical or relativistic energies. The energy which the new betatron gives to electrons is 20 million electron volts. With this source of high energy electrons one can create extremely energetic x-rays, and the nuclear-photo effects requiring on an average 6 to 8 million volts can be produced. Generally in the photo effect an x-ray or gamma ray photon of energy greater than the binding energy of a neutron within the target nucleus reacts with that nucleus and ejects the neutron somewhat like the electrons are ejected from the cathode in an ordinary photo-electric cell. The resulting nucleus is frequently radioactive, and the binding energy of the nucleus to be disintegrated can then be easily determined by finding the energy of the betatron at which production of radioactive material commences. The electrons themselves can be used to eject the neutron for the nucleus responds to the passage of an electron with its associated electric field in the same way but to a lesser extent than it responds to high energy photons.

Since we now have available a source of highly penetrating x-rays and a source of electrons of an energy so great that they can penetrate approximately half way through the human body, the uses to which the betatron can be put are not only experimental but very practical. X-rays are widely used in numerous practical ways industrially, and the radiations from the betatron are more penetrating than any others which have been produced.

The high energy electrons which escape from the accelerator by scattering off of the x-ray target form a very intense but somewhat divergent beam of electrons. Such high energy electrons when sent into the human body would produce a trail of ionization having the same destructive effect as x-rays which are at present used for therapy of deep tissue. One of the disadvantages of x-rays is that they do not stop somewhere within the body, but they penetrate completely through it and produce a biological effect, not only at the entrance surface and at the tissue being treated, but also at the exit side of the body. Various techniques are used in an attempt to create an optimum of ionization at the deep malignant tissue; but the advantage which penetrating electron rays have is that their range is finite and proportional to the energy of the electrons. The 20 million volt electrons from the betatron would penetrate 10 centimeters into the body and no more. Dr. Phillip Morrison estimates that the maximum ionization produced by these rays would be at about 7 or 8 centimeters below the entrance surface of the body. This means that the damage produced by an electron beam

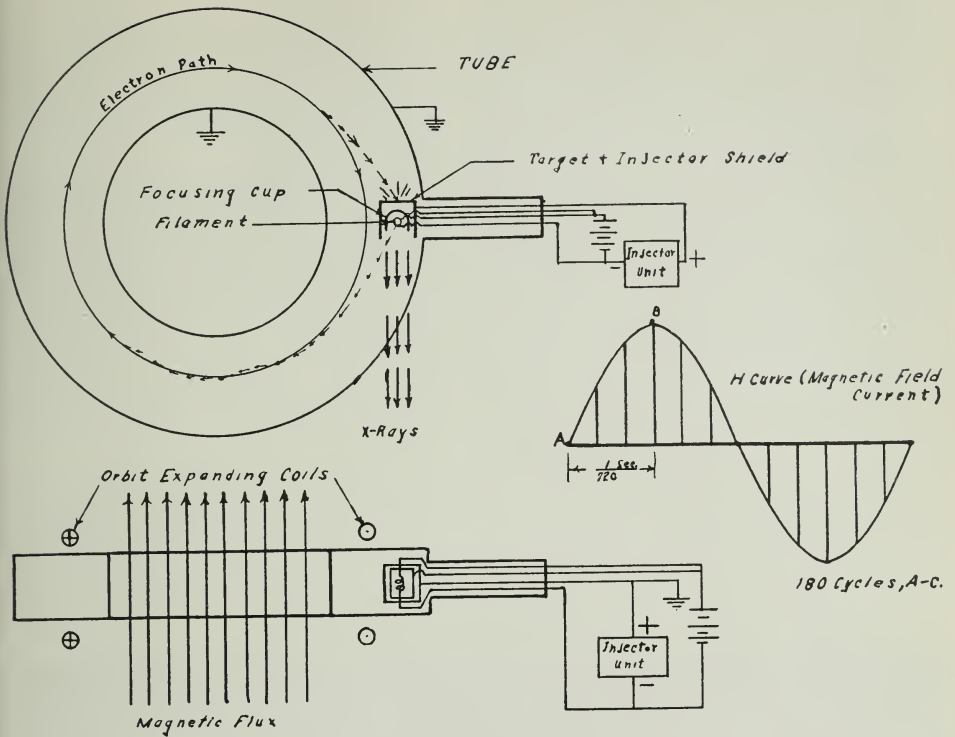


Fig. 1.—The vacuum doughnut in which the electrons are accelerated. Electrons going from the injector to the equilibrium orbit actually circle the tube many times before reaching the orbit. The same is true for electrons leaving the orbit to hit the target. Electrons are injected at A, and the orbit is expanded at B in every cycle.

can probably be localized fairly well on the tissue which is irradiated, a smaller amount of damage being done on the entrance side of the body and no damage being done beyond the tissue irradiated. When the beam of electrons in the betatron can be brought out without being scattered from a target, it will be more homogenous and less divergent, which will make the betatron more applicable to this very practical problem.

OPERATION OF THE BETATRON

The betatron looks in some respects like a miniature cyclotron since it is a magnetic device; but it operates with an alternating magnetic field instead of a uni-directional field. The theory of the betatron shows that relativistic effects encountered when the speed of light is approached do not hinder the operation in any way.[1] Electrons from an electron gun, called the injector, are shot into a circular path in a low intensity magnetic field. As these electrons circulate between the poles of the magnet, the magnetic field increases, and the time rate of change of flux linking the orbit produces a voltage gain per revolution equal to the voltage which would be read on a voltmeter connected to a one-turn coil placed at the orbit and reading instantaneous voltage.

Fig. 1 shows a sketch of the circular vacuum tube or doughnut in which the electrons leave the injector, circulate the magnetic field many times picking up energy at every revolution, and strike the back end of the injector, after they have been accelerated, where they produce x-rays. The orbit expanding coils are energized after the electrons have been accelerated, and they disturb the flux distribution near the electron path causing the electrons to spiral out to the target. The electrons are injected at the time indicated by A on the graph of magnetic

[1] D. W. Kerst, Phys. Rev. 60, 47 (1941). D. W. Kerst and R. Serber, Phys. Rev. 60, 53 (1941).

field, and the orbit is expanded to the target at the time indicated by B when the energy is at its maximum. These processes are repeated in each cycle.

The increase in flux linkage supplies momentum to the electron, and were not the magnetic field at the orbit of the electron increasing simultaneously, the orbit would become larger and larger and soon strike the outer wall of the acceleration chamber. To hold the electron in a fixed orbit it is necessary to make the magnetic field at the orbit increase in proportion to the momentum produced by the increasing flux linkage. The radius of curvature, r, of the orbit is related to the momentum of the electron and the size of the magnetic field, H, as follows: $mv = (e/c)\ Hr$. This calls for a special distribution of magnetic flux density, as we shall see. By Newton's second law the time rate of change of momentum is equal to the force on the electron; or $d(mv)/dt = f$, and the force, f, is the energy gained per centimeter of path, which assuming that the electron orbit has a fixed radius, r, is $(e/c)\ \phi/2\pi r$ where ϕ is the flux linking the orbit, e the charge of the electron, and c the velocity of light. Integrating the time rate equations, we get $mv=(e/c)\ (\phi-\phi_o)/2\pi r$, showing that the momentum is proportional to the change of flux within the circular orbit. Equating this momentum to $(e/c)Hr$ we get $\phi-\phi_o=2\pi r^2H$; which shows that if ϕ_o is zero when H is zero, the flux linking the orbit is proportional to the field at the orbit and must at all times have the value twice that which would exist if the field H were uniform within the orbit.

This result was obtained by making the assumption or r constant. Naturally the converse must be established and was established before the accelerator was built, that is, given this flux distribution, then the orbit has a fixed radius.

No mention has been made of the time dependence of the flux and field. It is merely necessary that the flux increase with time and that the field increase proportionately. This is easily accomplished by having both H and ϕ produced in an air gap by the same magnetic circuit. In practice the magnet and its coils correspond to an inductance in a resonant circuit. A great number of condensers are used to produce resonance at the desired frequency. On the original betatron made at the University of Illinois a frequency of 600 cycles per second was used, and 180 cycles per second is used on the 20 million volt betatron which was made while on leave of absence at the General Electric Company.

The requirement for the production of a beam of electrons in the accelerator is that stray or scattered particles deviated from the desired orbit by encounters with the residual gas molecules in the vacuum chamber be brought back to the orbit by focusing forces. The stray electron must oscillate about this orbit, called the equilibrium orbit, with a decreasing amplitude of oscillation, or the damping must be so great that it never crosses the equilibrium orbit.

By shaping the magnetic field properly the conditions for oscillation can be fulfilled. For axial oscillation the lines of force must bulge outwardly between the poles. The electron finds itself in a magnetic field with a slight radial component if it deviates from the median plane. This radial component has opposite directions on opposite sides of the median plane, and it forces the electron back toward this plane no matter which way the displacement occurs. To make the field bulge outwardly between the poles it is merely necessary to have the air gap increase with increasing radius. In practice this is done with approximately conical pole faces except for a slight lip at the rim of the pole face to correct for the rapid drop in field intensity which occurs at this point.

The condition for radial oscillation is that the magnetic field must not decrease more rapidly than 1/r. This can be understood from Fig. 2 which shows the curve of required centripetal force to hold the electron in the radius, r, as a function of r. This is a hyperbolic curve, since $F_c = m\ v^2/r$. The magnetic force Fm which is supplied by the magnetic field is $F_m = (e/c)\ H\ v$. In the betatrons which have been made, v changes so slightly during several focusing oscillations that this change can be ignored for the present. Consequently, if the radial dependence of Fm, and hence of H, is as shown in Fig. 1, it will supply more than the required centripetal force when r is greater than r_o and less when r is less than r_o. Should an electron be outside the equilibrium orbit, it would be in a region where the magnetic field was stronger

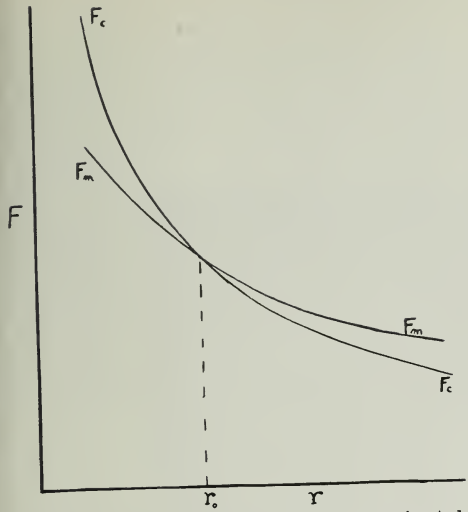


Fig. 2.—$F_c = mv^2/r$ is the centripetal force required to hold the electron in a circle of radius, r. $F_m = (e/c)Hv$ is the magnetic force which is actually supplied to the electron. The equilibrium orbit is at r_o.

than that necessary to cause a circular path. Its orbit would bend in toward the equilibrium orbit and, on crossing, the electron would find itself in a region where the magnetic field does not quite supply the required centripetal force; so the electron goes outwardly. This oscillation about the equilibrium orbit eventually dies out. The decrease in the amplitude of oscillation is a result of the increase in the magnetic field during the period of oscillation. The amplitude is proportional to $H^{-\frac{1}{4}}$. To a certain extent this is analogous to the stiffening of a spring which holds an oscillating mass. The damping properties of the increasing magnetic field make possible the whole process of injecting electrons so that they are trapped in a fixed orbit.

These axial and radial focusing actions succeed in forming a minute electron beam which strikes the target at a small focal spot. The x-rays produced cast very sharp shadows because the rays come from practically a point source.

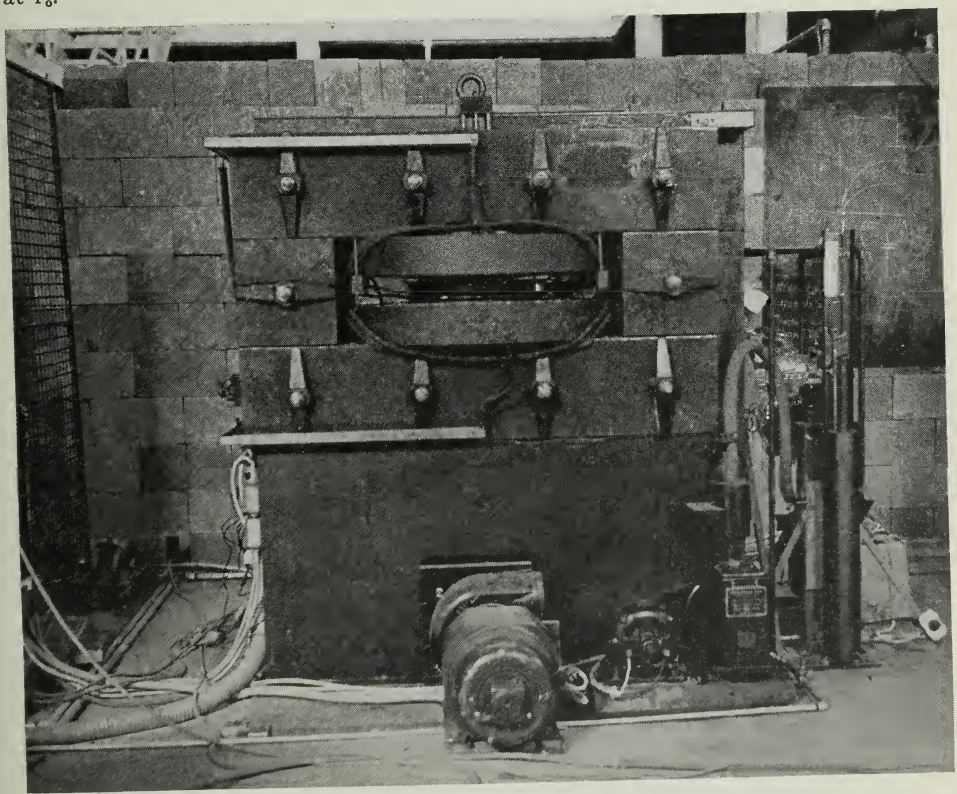


Fig. 3.—The new 20 million volt betatron. The light showing in the doughnut between the poles is from the injector.

The target is not melted by this fine beam because very little current is used. Approximately one microampere in the 20 Mev betatron suffices to produce 16 r per minute at one meter. The total number of watts in the beam is thus 20 and at this high energy the efficiency of x-ray production is so great that about 65 per cent of this beam energy is given off in x-rays and only the remainder heats the target.

The photograph in Fig. 3 shows the new 20 million volt betatron with the light coming from the injector at the edge of the doughnut between the poles. This accelerator has a 19-inch pole face diameter and an equilibrium orbit of 7.5 inches radius. The magnetic structure is only three feet high and five feet long; but it weighs about 3.5 tons. It requires about 25 kilowatts to operate it at 20 million electron volts at an oscillating frequency of 180 cycles per second. The cooling of the magnetic circuit is provided by the blower in the base of the magnet.

Not only is this accelerator capable of producing the usual x-ray effects with rays of greater penetration, but the radioactivities produced by photodisintegration in numerous substances have been observed, and the energy is sufficient for some small scale cosmic ray effects.

A NATURALIST IN THE SOUTH SEAS

Excerpts From Lecture By Karl P. Schmidt

Chief Curator, Dept. of Zoology, Field Museum of Natural History, Chicago, Illinois

THE ROMANTIC interest in museum expeditions to far-away and exotic regions in search of collections for study and display is still greater when such an expedition is foot-loose in a beautiful sailing yacht and one is able to visit out-of-the-way islands and cast anchor in little visited ports. . . . . Our glimpse of the islands of the Pacific will take us through the Polynesian Archipelagos, to the islands of Melanesia, inhabited by curly-headed black peoples, and to the great island of New Guinea, now so familiar and so vitally important to us in the daily news.

The Galapagos Islands have formed a focus of biological interest since the visit of Charles Darwin in 1835, and have become familiar to naturalists during the following century from the visits of successive expeditions and groups of scientists. It is noteworthy that the scientific interest of these extraordinary islands is not yet exhausted, and that they are now of the utmost political and military interest to us in the present war.

Far-off islands and ports visited by the Crane Pacific Expedition have now fallen into the hands of the Japanese. It is interesting that one of the services naturalists can offer to the war effort springs from their knowledge of the geography of such regions, now suddenly become of the most vital importance to us and to our sons.

(This lecture was accompanied by colored slides.)

FRANK COLLINS BAKER

DECEMBER 14, 1867, TO MAY 7, 1942

THOUGH he never at any time held a teaching position, few scientists of the present day have had greater influence in directing and stimulating interests of students than had Frank Collins Baker. Through his genial personality, his generous kindliness, his published researches, and his displays in museums, unnumbered thousands are included within the sphere of his scientific influence. Several prominent younger scientists, in such diverse fields as geology, anthropology, entomology, and zoology have acknowledged Mr. Baker's kindly and sympathetic interest as one of the important factors in their ultimate determination to devote their lives to scientific pursuits. But these careers, directly motivated by contacts with an understanding spirit are but one item in the evaluation of his broad influences.

Under his guidance the system of loan exhibits for the Chicago schools was inaugurated by the Chicago Academy of Sciences. As an outgrowth of this program thousands of children were given their first contacts with and interest in the study of nature.

His published works, especially those on the Mollusca and on the Life of the Pleistocene, have been and continue to be source books for all students of these subjects.

Mr. Baker became, for a short time, curator in the newly established Field Columbian Museum in Chicago (1894) after having received professional background and training in Brown University, in the Philadelphia Academy of Sciences, and in Ward's Natural Science Establishment of Rochester, New York. This was followed immediately by his appointment to the curatorship in the Chicago Academy of Sciences (1894-1915) where he developed techniques of museum display along with an absorbing interest in research.

For two years (1915-1917) he carried out a most comprehensive evaluation of the relations of bottom faunas to fish life for the New York State College of Forestry, at Syracuse.

Following this period, at the height of his professional career, he became curator of the Museum of Natural History in the University of Illinois where he devoted 21 years (1918-1939) to building one of the finest teaching museums on this continent. All this while he was pushing forward a research program which

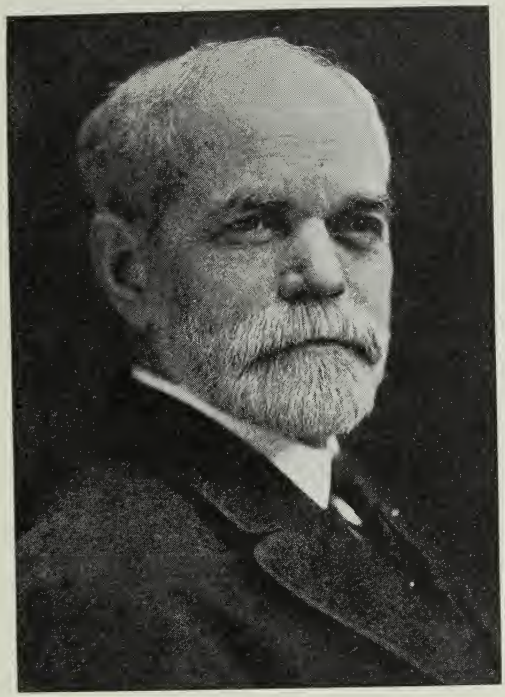
brought him eminence in the fields of the fresh water and land Mollusca and Pleistocene paleontology. Under his curatorship a third museum interest was expanded, namely, the building of study collections. The most widely recognized of these are in the fields of Mollusca, Paleontology, and Archaeology of Illinois.

Some of the scientific societies in which Mr. Baker held membership are: Fellow of the Geological Society of America; Fellow of the Paleontological Society of America; Fellow, American Association for the Advancement of Science; Corresponding member, Zoological Society of London; Life member, Illinois State Academy of Science (Sec'y. 1911, Vice-president 1931); Life member, Chicago Academy of Sciences (Sec'y. 1894-9; 1908); Museums Association of Great Britain; American Association of Museums (Councilor 1914-6); Ecological Society of America; Ottawa Field Naturalists Club; Sigma Xi; American Malacological Union (President in 1942).

Mr. Baker was a prolific writer. A complete list of his published books and articles totals close to 400 items. Of these, several stand out as distinguished contributions while the remainder comprise short notes and numerous more extensive articles. The best known of his books are *The Mollusca of the Chicago Area* (2 vols., 1892, 1902); *The Lymnaeidae of North and Middle America* (1911); *The Productivity of Invertebrate Fish Food on the Bottom of Oneida Lake, with Special Reference to Mollusks* (1918); *Life of the Pleistocene or Glacial Period* (1920); *Mollusca of Wisconsin* (2 vols., 1928); *Fieldbook of Illinois Land Snails* (1939).

Since his retirement from active service in 1939, as Curator *Emeritus*, he has devoted his full energies to research. Illness interrupted his work on a two volume monograph upon the Planorbidae which had been his major interest for many years. This work was expected to be the *magnum opus* of his research career. Death wrote the word "Finis" at the close of the manuscript for the first volume.

H. J. Van Cleave



EUGENE DAVENPORT

1856-1941

EUGENE DAVENPORT, born of pioneer parents near Woodland, Michigan, June 20, 1856, died on his old home farm, March 31, 1941, in his eighty-fourth year. He was graduated from the Michigan Agricultural College in 1878. After several years on his farm he returned to the Michigan Agricultural College for graduate work, receiving the degree of Master of Science in 1884. He was president of the Collegio Agronomica, Brazil, during 1891-92, serving as its first president. He became Dean of the College of Agriculture, University of Illinois, in 1895, Director of the Agricultural Experiment Station and Professor of Thrommatology, January 1, 1896, Director of the Agricultural Extension Service in 1914, and Vice President of the University in 1920, which position he held until his retirement on September 1, 1922. After his retirement he was recalled to active service to assist the President for a period of several months in 1929.

The honorary degree of Doctor of Laws was conferred upon Dean Davenport by Michigan State College in 1907, by the University of Kentucky in 1913, by the University of Illinois in 1931, and the degree of Doctor of Science by Iowa State College in 1920.

He was the author of several books and many articles in various periodicals. During the nineteen years of his retirement he did a great deal of lecturing and writing. His deeply ingrained characteristic of always seeing ahead, planning ahead, anticipating events was expressed at the end of his work for a bi-weekly agricultural journal to which he contributed a column. At the time of his death he had prepared enough material to

carry the column on for ten issues. Another important contribution since his retirement was a special investigation for the National Research Council.

To all of his work Dean Davenport brought clear thinking unhampered by petty details and prejudices which bias so many conclusions. His independence of thought and his far-reaching views of the problems of agriculture had their roots in the simpler pioneer life into which he was born and in which he lived through the most formative period of his life. His strength came not only from his love of people but from the great out-of-doors in which he found keen delight. In his book "Vacation on the Trail," he says concerning the mountaineer: "Brother to the peaks and the snow fields and the vast amphitheaters of green and white and gray that have guarded the passes since the world was young; friend to the timber, the waters, and the wild flowers; companion to the clouds and the shadows and drifting mists, the lightnings and thunders and the storms; neighbor to the very stars at night that seem to beckon one to step off the edge and be with them!"

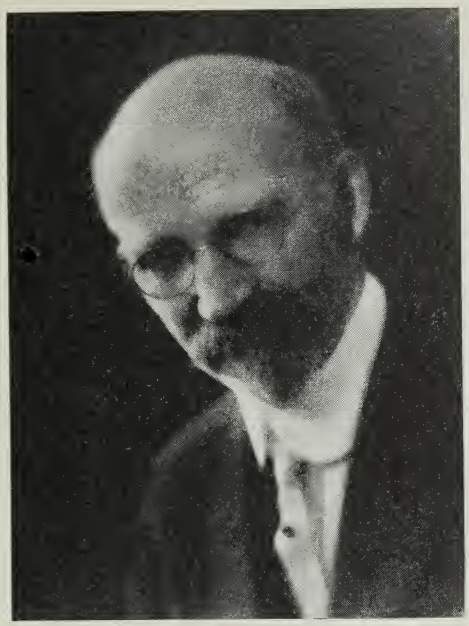
A statesman in all his approaches to educational and agricultural policy, Dean Davenport always considered the ultimate welfare of all the people. Temporary discomfort or even distress could be weathered, a slow beginning in a new venture could be tolerated, if the ultimate goal was right and the principles by which it was to be achieved would stand the test of time. At this point there was no room for compromise or expediency.

The core of his educational philosophy will be found in such statements as the following taken from an address which he gave in 1908. "The great mass of human happiness will always arise out of doing well the common things of life, and the happiness of the individual will lie in that creative genius which does today the same thing it did yesterday but does it better—the enduring things will always be the useful things. There will be no educated aristocracy, for education will have a higher purpose than to give one man an advantage over another. . . . There is no higher duty now resting upon all of us, and especially upon educators, than to unite education and activity by the closest possible bonds, to prevent on the one hand the acquirement of knowledge to no purpose, and on the other the development of operative skill with little knowledge of the true relations of things; to see to it that no individual shall be compelled to choose between an education without a vocation, and a vocation without an education. . . . What we need as a nation and a people is not simply more knowledge, but higher ideals. More of humility in success and more of fortitude in adversity. More of confidence in our fellows, and more of faith in the future."

Dean Davenport's influence was felt in all parts of the world, not only through the students who came to the University of Illinois from other countries, but as a result of his vigorous leadership in scientific research and educational policies. The esteem in which he was held was expressed in a message from Sir John Russell, of Rothamsted, England, which came to Dean Davenport on his eightieth birthday: "You have served not only your own country but the whole civilized world. May the rest of your days be in peace and in the knowledge that you have the affection of many friends in many countries."

In the passing of Dean Davenport we have lost a great leader, a man of high professional record and personal accomplishment, of rich service to mankind, a loyal friend—one with whom we are all proud to have been associated. Our consolation is that the influence and inspiration of such a life will continue in ways beyond our power to measure.

J. C. Blair
W. L. Burlison
H. E. Cunningham
C. F. Hottes
E. Roberts



FRANK SMITH

FEBRUARY 18, 1857, TO FEBRUARY 3, 1942

Frank Smith came to the Urbana campus in 1893. From the first, he held dual appointments on the staff of the Illinois State Laboratory of Natural History under Professor Forbes and on the University faculty in the Department of Zoology. His earlier experiences had consisted of collegiate training in Hillsdale College, in Michigan, and graduate study in Harvard, under Professor E. L. Mark, ending in a Master's degree in 1893. He had been Professor of Chemistry and Biology in Hillsdale College (1886-1892) and had taught Biology in Trinity College, Hartford, Connecticut (1892-3). The summers of 1886 and 1887 were spent in special study in the Anasquam, Massachusetts, marine station and that of 1891 found him under the influence of Alexander Agassiz in the Newport, Rhode Island, Marine Laboratory. The summer of 1893 he was engaged by the Michigan Fish Commission as a member of a group studying the biology of Lake St. Clair.

These early experiences in field laboratories peculiarly fitted him for the work which he was about to undertake for the Illinois State Laboratory of Natural History. He was made superintendent (1894) of the Biological Station on the Illinois River at Havana, under the joint sponsorship of the University and the State Laboratory. Here he helped to formulate and execute the early program of studies on the biology of the Illinois River.

The interests there aroused were kept alive at a much later date in his teaching of courses in field zoology in the University of Illinois and as a member of the faculty of the University of Michigan, teaching summers in the biological station on Douglas Lake.

In the University and throughout the Middle-west his long period of continuous service and his broad personal contacts made him a continuing agency between the old and the new developments in the zoological sciences. Not content to watch the opening up of the new fields, he took an active part in their development. As early as 1901 he was offering a course in Statistical Zoology in the University. In this course, before any specific instruction in evolution and heredity was given in the Department of Zoology, he taught the applications of mathematical analysis to

problems of "variation, heredity, distribution, and phylogeny."

His interests in teaching greatly influenced the direction of development of zoological courses in the University of Illinois, where he was advanced to a professorship in 1913. In 1923, Hillsdale College, his alma mater, conferred on him an honorary D.Sc. degree.

His earliest research was in marine zoology, but in the Middle-west, where he was to spend the remainder of his active career, he early undertook a program of studies on the earthworm fauna which led to his becoming recognized as the leading American authority on this group.

Another field of interest for both teaching and research was that of ornithology. Long years of daily observations on spring bird migration furnished data on which he correlated migratory movements with changes in wind and weather. After retirement, he found time and opportunity to carry on bird banding in his Michigan home during the summer months and in Florida during the winter.

From 1900 to 1917 he was curator of the museum of Natural History of the University of Illinois, performing this as a service to the University in addition to a relatively full program of teaching and research.

With his interest in the fauna of the state it was only natural that he was actively interested in the Illinois State Academy of Science, in which he held life membership. His memberships in scientific organizations were chosen with the same discrimination with which he chose his personal friends. They included the American Association for the Advancement of Science, the American Society of Zoologists, American Society of Naturalists, American Ornithologists' Union, and Sigma Xi. For many years he served as consulting specialist to the U. S. National Museum and to the U. S. Department of Agriculture.

The qualities of unassuming modesty and uncompromising honesty marked all of his relations with both students and associates.

H. J. Van Cleave

STATE OF ILLINOIS

DWIGHT H. GREEN, Governor

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ILLINOIS STATE MUSEUM DIVISION, CENTENNIAL BUILDING

SPRINGFIELD, ILLINOIS

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1943 MEETING AT JACKSONVILLE MAY 7-8

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TRANSACTIONS OF THE ILLINOIS STATE ACADEMY OF SCIENCE

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ANNOUNCEMENTS

Attention is directed to the fact that the Committee on Research Grants of the Illinois State Academy of Science has at its disposal a small sum of money to be disbursed in support of worthy research projects. Applications for grants will be accepted up to and including March 31, 1943. It is customary to give preference to scientists connected with the smaller institutions of the state.

Requests for grants should be accompanied by a brief statement of the training and experience of the applicant, the purpose of the investigation, and the estimated cost. Previous publications should be listed. At least two letters of recommendation should be transmitted directly by their authors. Correspondence may be addressed to L. H. Tiffany, Northwestern University. Evanston, Illinois.

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1943 MEETING: JACKSONVILLE, MAY 7-8

PAPERS IN AGRICULTURE

FROM THE REPORT OF THE SECTION CHAIRMAN

Eleven papers were presented at the Urbana meeting, 8 of which are herewith published. The others were:

SPENCER, E. R., McKendree College, Lebanon, Ill.—*The Practical Side of the Nitrogen Cycle.*

DORSEY, M. J., University of Illinois, Urbana, Ill.—*The use of genetics in solving the variety problem for peach growers.*

ROBERTS, E., University of Illinois, Urbana, Ill.—*Cross-breeding in swine.*

Thirty attended the meeting and elected O. L. Whalin, University of Illinois, chairman for 1942-43 meeting at Jacksonville.

(Signed) C. H. OATHOUT, *Chairman*

GERMINATION STUDIES OF BROMEGRASS SEED, *BROMUS INERMIS* LEYSS

R. F. Fuelleman and W. L. Burlison

University of Illinois, Urbana, Illinois

Difficulties attending the seeding of bromegrass have given impetus to investigations of methods of processing bromegrass seed to facilitate its seeding with ordinary farm machinery. The seed is relatively large and light in weight. Caryopses are rather loosely held within the lemma and palea. Both of the latter are nearly equal in size and the paleas are slightly ciliated. Caryopses are slightly curved, with the point of attachment to the rachilla rather abruptly turned in. This brief description is included in an attempt to better illustrate the reasons for difficulties encountered in seeding and processing the seed without damage.

Farmers have been hesitant to use this excellent forage grass because it has necessitated the use of a vehicle to carry it through ordinary seed drills. Attempts to seed it alone with a drill usually results in "bridging," and a nonuniform seeding results. Various agitator attachments have been recommended but most drills are not constructed to use these agitators. This has made hand seeding necessary. Here again, considerable difficulty is encountered in obtaining uniform seedings of bromegrass, particularly on windy days. This paper reports some results of germination studies in the greenhouse with untreated bromegrass seed, hulled seed, and seed from which the hulls were removed by abrasive action. Treatment was intended as a means of facilitating easy and effective seeding. The effect of depth of planting is also considered and reported.

Source of Seed and Treatment.—The seed used in these experiments was produced in southeastern Illinois, on the Agronomy South Farm at Urbana in 1941, and at the Soil Conservation Service regional nursery located at Elsberry, Missouri.*

Three lots of seed were used in the so-called treatment tests: Lot 1, seed not subjected to special processing or selection—whole seeds taken from an ordinary lot of seed; Lot 2, naked caryopses selected from seed after it had passed through the combine; and Lot 3, hulled seed from which lemmas and paleas were removed by using an abrasive. In preparing the hulled seed, sandpaper was first used, but it proved to be too severe. This method seriously damaged most of the caryopses. In the second method, the lemmas and paleas were removed by means of rubber buffers. No observable damage to caryopses occurred with this method. The third method utilized a hammer-mill, a machine first used experimentally for commercial seed treatment. A fourth method consisted of rubbing seed gently between a wood block and a stone table top.

Untreated seed from Lot 1 was used in depth of germination experiments. Whole seeds were planted on greenhouse benches at depths of ¼, ½, ¾, 1, 1¼, and 1½ inches. Germination counts and measurements of seedling growth were made. Temperature, moisture, and light conditions were the same for all depths of planting.

Results of Germination Tests Treatment Series.—Germination percentages of the different lots of seed were closely related to the severity of treatment. Whole seed, or seed that retained the lemmas and paleas, gave normal germination under greenhouse conditions. A slight drop in germination during the period from January 8 to 20 was due to slightly lower temperatures in the greenhouse, and coincided with low outdoor temperatures. This lot of seed was of high quality and good germinability (See Table 1).

The second lot of seed, selected from the first lot, but with lemmas and paleas

* Acknowledgment is made to Mr. Walter Newlin of Casey, Illinois, for seed and his deep interest in these investigations; also to Mr. C. J. Coukos, Soil Conservation Service, Elsberry, Missouri.

absent, gave an average germination considerably lower than the first. All conditions were similar to those of the first lot. The seed was accidently hulled in the process of combining. Examination of the caryopses showed no observable damage which might account for lowered germination.

The third lot consisted of seed from which lemmas and paleas were removed either by (1) rubbing with sandpaper—obviously too severe, (2) the use of a rubber buffer, (3) the hammer-mill, or (4) rubbing with a board on a smooth concrete slab. Methods 1 and 3 proved most damaging (Table 1). The hammer-mill was previously considered as having the greatest potential use in seed processing but these results indicate that it is too severe, destroying the viability of a large percentage of seeds. From the practical point of view, the second method, i. e., using a rubber buffer, has more potentialities than any method of treatment by which the chaffy and light seed coverings are removed.

TABLE 1.—PERCENTAGE GERMINATION OF SEEDLINGS AT THE END OF EACH 12-DAY PERIOD

Sample no.	Period	Replications[1]					Average
		1	2	3	4	5	
Whole Seed Germinations		pct.	pct.	pct.	pct.	pct.	pct.
1	11/8—11/21	96	80	96	96	86	90.8
2	12/1—12/12	96	94	92	92	92	93.2
3	1/8— 1/20	92	86	80	92	96	89.2
4	2/2— 2/14	90	96	98	96	94	94.8
Hulled Seed Germinations							
1	11/8—11/21	74	72	86	80	86	77.6
2	12/1—12/12	80	86	86	76	74	80.4
3	1/8— 1/20	58	66	68	58	48	59.6
4	2/2— 2/14	70	70	78	68	60	69.2
Damaged Seed Germinations							
1	11/8—11/21	6	2	6	8	12	6.8[2]
2	12/1—12/12	46	40	60	68	68	56.4[3]
3	1/8— 1/20	22	30	34	18	26	26.0[4]
4	2/2— 2/14	70	70	78	68	60	69.4[5]

[1] Each replication consists of 50 seeds.
[2] Sandpaper.
[3] Rubber buffer.
[4] Hammer-mill.
[5] Rubbed with board on concrete.

Seedling Growth.—Height of seedlings in centimeters is not a direct indication of seed treatment but apparently combines the effect of interactions of temperature, light, and moisture. Seedling heights of the three lots of seed are shown in Table 2. Germination and height of seedlings seem to be related although it is probable this relationship would diminish with time under greenhouse conditions. Under field conditions, the stronger initial growth of seedlings may well favor more rapid establishment, an important factor in economical pasture husbandry.

Depth of Planting.—Rates of seeding bromegrass as well as other species are usually heavy enough to care for variations in soil, seedbed, and climatic factors. Much seed is planted too deeply and results in uneven stands due to failure of the plants to emerge. Seed size obviously is important. Bromegrass seed is large and can be planted at greater depths than the smaller seeded species, such as redtop, *Agrostis alba*, or Kentucky bluegrass, *Poa pratensis*.

In this experiment, bromegrass was planted at depths of ¼, ½, ¾, 1, 1¼, and 1½ inches, respectively. Emergence of seedlings did not vary greatly with the first four depths; however, the emergence percentage was distinctly lower with the 1¼ and 1½ inch depths.

Conclusions.—Within the scope of these experiments certain conclusions are apparent: (1) Untreated seed (unhulled) is definitely higher in germination than hulled seed (naked caryopses) regardless of how the hull was removed. (2) Seed planted at depths greater than one inch is lower in emergence than seed planted at shallower depths.

TABLE 2.—SEEDLING GROWTH IN CENTIMETERS AS MEASURED DURING GERMINATION PERIODS

Sample no.	Period	Replications[1]					Average
		1	2	3	4	5	
Height of Seedlings from Whole Seed		cm.	cm.	cm.	cm.	cm.	cm.
1	1st	8.2	8.3	8.0	8.0	7.6	8.0
2	2nd	5.8	5.6	5.8	6.3	6.3	6.0
3	3rd	6.6	6.1	6.7	6.0	6.6	6.4
4	4th	6.0	6.0	6.6	6.3	6.3	6.2
Height of Seedlings from Hulled Seed							
1	1st	7.0	7.3	7.1	6.9	7.3	7.1
2	2nd	5.7	5.6	5.7	5.4	6.1	5.7
3	3rd	5.9	6.0	5.8	5.8	5.9	5.9
4	4th	3.9	4.6	4.1	4.6	4.3	4.3
Height of Seedlings from Damaged Seed							
1	1st	2.0	2.7	2.1	1.9	3.2	2.3
2	2nd	5.9	5.4	5.0	5.2	5.3	5.4
3	3rd	3.3	4.2	5.2	4.8	4.5	4.4
4	4th	4.1	4.2	4.2	4.3	4.7	4.3

[1] Each replication consists of 50 seeds.

TABLE 3.—GERMINATION OF BROMEGRASS SEED WHEN PLANTED AT VARYING DEPTHS

Depth of planting inches		Replications[1]					Average	S. D.
		1	2	3	4	5		
¼	Perct. germination	90	96	98	96	94	94.8	2.71
	Seedling height, cm	6.0	6.0	6.6	6.3	6.3		
½	Perct. germination	96	88	98	92	90	92.4	3.74
	Seedling height, cm	5.8	5.5	5.4	5.7	5.8		
¾	Perct. germination	96	98	98	90	94	94.2	2.98
	Seedling height, cm	4.7	4.6	4.7	5.0	5.2		
1	Perct. germination	98	88	90	90	82	89.6	5.12
	Seedling height, cm	4.8	4.8	5.0	4.8	4.8		
1¼	Perct. germination	82	82	88	84	86	84.8	2.35
	Seedling height, cm	4.4	5.0	4.6	4.1	4.8		
1½	Perct. germination	86	74	78	82	72	78.4	3.96
	Seedling height, cm	4.9	3.9	4.6	4.4	4.0		

[1] Each replication consists of 50 seeds.

RESULTS OF EXPERIMENTS IN IMPROVEMENT OF PASTURES FOR DAIRY CATTLE

W. B. Nevens

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Seven years' trials at the Illinois Station with pasture crops for dairy cattle have shown possibilities for greatly increasing (a) the length of the pasture season; (b) the yield of pastures; and (c) the length of time fresh green pastures are available, as compared with ordinary bluegrass pastures. These results have been accomplished through (a) selection of suitable, high-yielding pasture crops; (b) good grazing management; (c) adequate and regular fertilization; and (d) persistent weed control.

High-producing pasture crops studied in the trials were alfalfa, bromegrass, a mixture of Sudan grass and soybeans, sweet clover, and winter rye. It has been found advantageous to grow a number of these crops simultaneously in separate fields and to pasture them in rotation or when the crops are at their best stages for pasturing.

Application of a nitrogen fertilizer to bluegrass pastures increased (a) the nitrogen content and (b) the palatability of the grass. An explanation for the greater palatability of the fertilized grass is the higher moisture content of the fertilized crop.

A study of thirty-seven comparisons of the dry matter of bluegrass taken from fertilized and from unfertilized pasture plots shows that in all but four cases the grass from the fertilized plots was lower in dry matter content (and thus higher in moisture content) than the grass on the unfertilized area. Of these four instances two occurred in August of 1940, an unusually dry season, when pastures were almost bare. An analysis of the data by the method of Student indicates a statistically significant difference in the dry matter contents of the fertilized and unfertilized grass. A summary of the

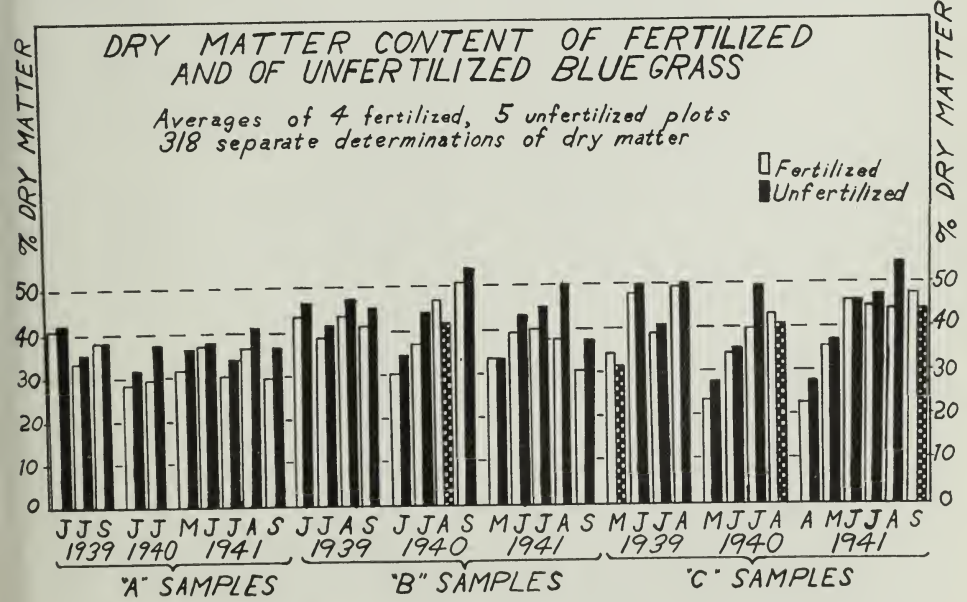

Fig. 1.—Over a 3-year period, fertilized bluegrass had a lower dry-matter content (remained greener) than unfertilized bluegrass.

data is presented in chart form in Figure 1. It is believed, therefore, that the main reason cattle select fertilized areas of pastures for grazing, in preference to unfertilized areas, is the higher moisture content of the fertilized crop. Other factors also may be operative, but these are believed to be of less importance than the dry matter content.

Further evidence that the dry matter content is the factor of principal importance in determining palatability of pasture crops is found in a study of the dry matter content of a number of pasture crops used in our trials. Samples taken during the months of April to September, inclusive, over a five-year period, show that bluegrass contains more than 30 per cent dry matter thruout a large portion of the pasture season, while a Sudan grass-soybean pasture rarely reached 30 per cent dry matter. There is a close relation between dry matter content and palatability, the crops lowest in dry matter, as a rule, being most palatable. (Table 1.)

TABLE 1.—DRY MATTER CONTENT OF PASTURE SAMPLES

Crop	No. of determinations	Samples over 30 percent dry matter	
		Number	Per cent
Alfalfa	71	17	24
Bluegrass	389	359	92
Brome grass	30	9	30
Sweet clover	16	6	38
Sudan grass—soybeans	38	1	3

THE CHEMICAL COMPOSITION OF FARM CROPS AS AFFECTED BY SOIL TYPE AND TREATMENT

H. J. SNIDER

University of Illinois, Urbana, Illinois

Farm crops in Illinois are grown on soils representing a large variation in natural fertility. Little attention has been given the probable effect that these various levels of soil fertility might have on the quality of these crops. Soil treatment, such as adding limestone, phosphates, potash, and legumes, has reached such proportions as to have a decided effect on the production of total crops in the state. Soil treatment is considered almost solely from the standpoint of increasing acre yields. The factor of quality which might be affected by the fertility of soils is as a rule not considered.

A recent publication, "Building Better Pastures,"* contains some statements which are highly pertinent to the conservation of soil fertility and which sooner or later must be given consideration by all who are interested in farm production. Some of these statements follow: "Good livestock are seldom found in poor soil areas." "Many soils are deficient in plant food elements, and as a result grass is poor and this deficiency is transferred to animals." "The relationship between soil fertility and health of livestock has been well established by research." "The object of this publication is to supply information regarding pastures to horsemen and stockmen throughout the continent, and in this connection these statements are of great significance."

It is the object of this paper to present briefly chemical data which supply information along the lines of the above quotations and limited to Illinois soil conditions. It is not always possible in chemical work to select all of the constituents which may cause human beings or animals to flourish or not to flourish on certain foods or feeds. It is possible, however, by chemical methods to show deficiencies or abundance of certain constituents or elements which may have considerable nutritive value. Protein is one of the important constituents of foods and its presence often determines the value of the product. Phosphorus is one of the important mineral elements and its deficiency has frequently led to disastrous

* By W. L. Burlison and R. F. Fuelleman, published by the Horse and Mule Association of America.

results in animal nutrition. This discussion will be limited to these two constituents of foods and feeds.

Experimental Results.—The results from three experimental fields are shown in Table 1; one field represents an intermediate while the other two fields represent almost two extremes in soil fertility. The composition of Kentucky bluegrass grown on these soils is also included. The Elizabethtown field represents Ava silt loam with a total nitrogen content of 1,580 pounds an acre on untreated soil. This soil produced bluegrass which had a protein content of 136 pounds per ton and a phosphorus content of 1.6 pounds per ton of air-dry hay. The Clayton field which represents Harrison silt loam containing 3,600 pounds an acre of total nitrogen produced bluegrass which contained 150 pounds of protein and 3.2 pounds of phosphorus per ton of air-dry hay. The Easton field representing the more fertile Harpster clay loam produced bluegrass which contained 162 pounds of protein and 3.6 pounds of phosphorus per ton of hay. The Kentucky bluegrass grown on the Harpster clay loam contained approximately 19 per cent more protein and 125 per cent more phosphorus than did the hay from the low fertility Ava silt loam which is typical of a large area of the southern Illinois hill lands. When differences of such high proportions as these are found it is not unlikely that animals fed too long on this phosphorus-deficient grass may suffer from diseases peculiar to such a deficiency.

The results for the bluegrass on the treated soils for the three fields were not exactly comparable because of variations in the amounts and kinds of fertilizers used. However, these results do indicate the enormous possibilities of these soils when well treated. The protein content was more than doubled by the use of nitrogen fertilizers while the phosphorus content on the Ava soil was doubled by the use of phosphate fertilization. Ammonium sulfate supplied the nitrogen fertilizer at Easton and Clayton while sodium nitrate was used at Elizabethtown. Superphosphate supplied the phosphorus at Elizabethtown and Clayton while at Easton the phosphorus was supplied by soybean meal.

The Kentucky bluegrass from the three fields (Table 1) was harvested at approximately the same stage of growth—full maturity. It is not probable that any considerable part of the differences was due to variations in the stages of growth of the grass.

The hay values in Table 1 are based alone on protein content at five cents per pound. This value is obtained from the market price of high-protein feeds such as tankage, soybean meal, alfalfa meal, etc.

The results in Table 2 show that soils in a relatively low state of fertility do not always produce grain of a low feeding value. The Kewanee field representing Muscatine silt loam with a total nitrogen content of 7,720 pounds an acre produced corn grain with 2.35 per cent less protein than that on the Enfield field. The last named field represented Bluford silt loam with a total nitrogen content of 3,100 pounds an acre. On the basis of the above protein content and valuation, the corn from the Enfield field was worth six and one-half cents per bushel more than the corn from the more fertile Kewanee soil. The Enfield grain had also a slightly better phosphorus content.

In this experiment, hybrid corn was used with identical soil treatment (RLPK) consisting of residues, limestone, rock phosphate, and potash.

Phosphorus and protein content of wheat grain, presented in Table 3, shows a decidedly lower content for grain grown on soils of relatively low levels of

TABLE 1.—COMPOSITION OF KENTUCKY BLUEGRASS FROM THREE DISTINCT FERTILITY LEVELS REPRESENTING BOTH TREATED AND UNTREATED SOILS

Experiment field	Soil Total N	Hay—Untreated soil			Hay—Treated soil		
		Protein	Ton value	Phos.	Protein	Ton value	Phos.
	lbs./A.	lbs./T.		lbs./T.	lbs./T.		lbs./T.
Elizabethtown	1580	136	$6.80	1.6	151	$ 7.55	3.2
Clayton	3600	150	7.50	3.2	226	11.30	5.8
Easton	4800	162	8.10	3.6	355	17.75	5.0

TABLE 2.—PROTEIN AND PHOSPHORUS CONTENT OF CORN GRAIN FROM TWO SOILS WITH IDENTICAL TREATMENT

Experiment field	Soil treatment	Soil Total N	Corn grain	Protein		Phosphorus Lbs./bu.
				Perct.	Lbs./bu.	
		lbs./A.	bu./A.			
Kewanee	RLPK	7720	91	9.25	5.2	.14
Enfield	RLPK	3100	82	11.60	6.5	.15

fertility. The Minonk field representing Drummer clay loam with a high nitrogen and phosphorus content on untreated land produced wheat grain which had 57 per cent more phosphorus and 13 per cent more protein than wheat grown on the Toledo field which represents Cisne silt loam with a relatively low nitrogen and phosphorus content.

Soil treatment which included a phosphate fertilizer gave an increase in phosphorus content of the grain of 64.2 per cent on the less fertile Cisne silt loam, while on the more fertile Drummer clay loam there was no apparent effect of the treatment on the phosphorus content of the wheat grain.

These data, although somewhat limited in scope, indicate that a decidedly unfavorable nutritional condition may exist in both food material and animal feeds due to low levels of fertility elements in our soils.

The above quotations regarding the effect of soils on the health and welfare of animals may appear to involve rather serious problems. We may be inclined to believe that these statements apply to some far-removed part of the country and dismiss them as problems which do not concern us directly. However, even a limited study of Illinois soil conditions indicates that the foregoing statements, serious as they may be, may at some time apply directly here in this state.

TABLE 3.—PHOSPHORUS AND PROTEIN CONTENT OF WHEAT GRAIN FROM TWO SOILS TREATED AND UNTREATED

Experiment field	Untreated soil		Phosphorus content of grain			Protein content	
	Total N	Phos.	Untreated	Treated	Increase	Untreated	Treated
	lbs./A.	lbs./A.	lbs./bu.	lbs./bu.	perct.	lbs./bu.	lbs./bu.
Minonk	6320	130	.22	.22	0	7.8	7.9
Toledo	2480	18	.14	.23	64.2	6.9	6.9

WHAT ARE WE DOING WITH CASTOR BEANS?

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The castor bean, fruit of *Ricinus communis*, a species belonging to the spurge family (Euphorbiaceae), has been cultivated for various purposes since Biblical times. It is the Palma Christa of the Egyptians, sometimes referred to as Jacob's gourd, and was the source of oil used in making papyrus. Ricinus is a Latin term meaning dog-tick, which the seed was thought to resemble.

Although the original habitat of this species was Africa, commercial production was and still is centered in Brazil and British India. Most North American supplies have been imported from Brazil. During the 19th century a number of attempts were made to introduce commercial production in the United States, particularly in southern areas. Between 1860 and 1916 castor beans were grown as a farm crop in some sections of Kansas, Oklahoma, Missouri, and Illinois. In 1879 Kansas produced a total of 750,000 bushels.[1] In 1918 castor beans were grown in many southern and western states to provide oil for special purposes. Several thousand tons were produced, but following the war importations increased and domestic interest declined. Since then a few beans have been grown, chiefly for experimental purposes.

Adaptation.—The crop is adapted to a wide range of soil and climatic conditions. Commercial production, however, is confined within the territory south of the 38 parallel of latitude.

Observations indicate that on rich soils castor bean plants grow vegetatively without a corresponding production of seed. On soils of average fertility, seed yields are more closely correlated with vegetative growth.

Commercial varieties are for the most part annuals attaining an average height of approximately six feet in south central Illinois. Seeds are about the size of large beans and contain from 35 to 55 per cent oil. These beans are found in spiny pods with a ratio of 65 to 80 per cent bean to hull by weight.

Composition of Castor Bean Plant and Oil.—The castor bean plant contains a substance, ricin, which is considered as having potential use in insecticides. In addition to oil, the seeds contain an alkaloid, ricinine, a poisonous substance belonging to the heterocyclic series of compounds of the pyridine group. The composition was determined by synthesis by Spath and Koller.[2] Castor oil contains a considerable percentage of the esterols of palmitic acid and ricinoleic acid, the latter having a replaceable hydroxyl group. This is mentioned because this factor is important in the dehydration process and its subsequent use as a drying oil.

Castor oil is a viscous liquid of the fixed oil group having a specific gravity of 0.958 to 0.968 at 15° C. The iodine number is 82 to 90, and the saponification value is 177 to 187. It is soluble in alcohol, ether, and petroleum ether.[3]

Imports of Castor Beans and Utilization of Oil.—Imports of castor beans increased very materially during 1940, reflecting a growing demand for castor oil for industrial use. See Table I.

Small quantities of castor oil are used for medicinal purposes, but most of the oil is used in the manufacturing and processing of industrial products such as artificial leather, soap, ink, linoleum, lubricants, paints, varnishes, and for use in dyeing fabrics. During World War I, castor oil was used extensively as a lubricant for airplane motors. It still has a place as a special lubricant and as a recoil absorbing liquid in armaments.

Investigations on Castor Beans and Oil.—Research on the castor bean is divided into agricultural and industrial investigations. It is difficult to separate these phases along clear-cut lines for both are

[1] Crooks and Sievers. Mimeo. pub. U.S.D.A.
[2] DeAlbe, Heterocyclic Compounds, 1923.
[3] Jamieson, Geo. S., Vegetable Fats and Oils. The Chemical Catalog Company, Inc., New York. 1932.

TABLE 1.—IMPORTS OF CASTOR BEANS AND ESTIMATED UTILIZATION OF CASTOR OIL

Year	Imports of castor beans	Consumption by drying industries
	1000 lbs.	1000 lbs.
1935	77,049	3,858
1936	164,077	4,794
1937	146,808	7,722
1938	114,072	6,043
1939	162,611	11,844
1940	237,789	24,858

interdependent. Agricultural research is concerned particularly with the production of the crop, including studies of environment, varieties and their soil adaptation, oil production, composition, cultural methods, and the development of machinery for harvesting. This brief statement encompasses a far-reaching program of agricultural research which eventually purposes to care for the wartime needs of the nation.

Research in industrial-chemurgical chemistry employs a utilization of practically all raw materials making up any part of the castor bean plant.

What Are We Doing With Castor Beans?—The Illinois Agricultural Experiment Station began preliminary work on this crop in 1938 with some large flowering varieties which were unsatisfactory in maturity and yield. In 1939, three varieties were obtained from the U. S. Department of Agriculture and one from Kansas. Small test plantings were made and the beans harvested. Increased plantings of these varieties were made in 1940. In 1941, a number of new varieties were obtained. These were included in the tests which were made at several locations in south central and southern Illinois. Yield data from three locations are shown in Table 2.

In addition to beans, in 1941 stalks were also harvested. Field observations have indicated these stems were strong and fibrous. Sample yields, following a period of field curing and drying, averaged approximately 5,000 pounds for all varieties. This material has considerable promise for use in the manufacture of paper boxes.

Plant Breeders Work on Improvement.—A number of important factors contribute to the difficulties of economical production of castor beans. A few are included here: (1) Nonuniform maturity, making it difficult to harvest all beans in a single picking; (2) tendency to shatter; (3) nonuniform height; and (4) some promising varieties mature too late in northern areas. The time elapsed since the initiation of this work has been too short for workers to obtain little

TABLE 2.—CASTOR BEAN YIELDS FOR 1939, 1940, AND 1941 AT URBANA, DIXON SPRINGS, AND ALHAMBRA, ILLINOIS

Variety	Yield			
	1939	1940	1941	Average
Urbana—Central Illinois	lb/A	lb/A	lb/A	lb/A
Arlington	466	1015.0	1554	1012
U. S. 4	701	1081.9	1376	1053
U. S. 7	1149.6	1052.0	1624	1275
Kansas Common	1175.2	1137.0	1570	1294
San Benita	----------	----------	1684	1684
Conner Type (Texas)	----------	----------	1544	1544
Conner Type (Mo.)	----------	----------	1296	1296
Doughty 11 (Texas)	----------	----------	1738	1738
MG Kentucky	----------	----------	1596	1596
Dixon Springs—Southern Illinois				
Kansas Common	----------	495.0	548.0	521.5
Arlington	----------	525.0	615.0	570.0
USDA 4	----------	490.0	595.0	542.5
USDA 7	----------	332.0	672.0	502.0
Alhambra—Southwestern Illinois				
Kansas Common	----------	----------	824.0	824
U. S. 7	----------	----------	1016.0	1016
U. S. 4	----------	----------	746.0	746
Arlington	----------	----------	904.0	904
MG Kentucky	----------	----------	952.0	952
Conner Type (Texas)	----------	----------	840.0	840
Conner Type (Mo.)	----------	----------	820.0	820

more than an indication of definite favorable trends which should lead to a solution of these problems.

Culture and Harvesting Castor Beans.—The planting and subsequent cultivation of castor beans are similar to corn, but the harvesting operations are more difficult. Significant research on better methods and means of harvesting and threshing this crop is under way.

In Illinois, castor beans are usually planted during May, depending upon soils and climatic conditions. Hand corn planters have been used, but it is possible to utilize regular corn planting machinery by substituting plates of correct sizes in the drill boxes. Rows are usually 40-42 inches wide, and plants are spaced either 36 or 40 inches in the row. Germination and emergence require approximately two weeks. Weeds are controlled by two or three cultivations with the corn cultivator; however, little care is necessary until harvest time after the plants have attained a height of 18-24 inches.

Combines have been used and show considerable promise that field harvesting will replace hand picking. A number of hulling machines have been built for removing beans from the capsules. The Illinois Agricultural Experiment Station evolved a small experimental huller which has been satisfactory. This problem is well on the way to a solution.

Agronomic research as proposed for 1942 is both intensive and extensive. A number of experiment stations are working in cooperation with the U. S. Department of Agriculture in a series of studies including the following: (1) Variety studies in 22 states; (2) planting dates in five states; and (3) spacing tests in five states. These are in addition to genetic studies already initiated.

Castor beans, as a crop, have shown the most promise in the large area between the cotton belt on the south and the corn belt on the north, centered near the southern tip of Illinois. It is realized that competition with other crops for space and labor limits this crop to the designated area.

RELATIVE PHOTOSYNTHETIC CAPACITY OF STALKS, LEAF SHEATHS, AND LEAF BLADES IN MAIZE AS MEASURED BY THE CONTRIBUTION EACH MAKES TO THE DEVELOPMENT OF THE GRAIN

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From the extreme reduction in grain yield associated with the removal of all blades (1, 2, 3) from maize plants one might conclude that no filling of the grain takes place after defoliation. In order to get data on this question a field trial was made using U. S. Hybrid 13 (WF9 x 38-11) (Hy x L317) in the summer of 1941 at Urbana, Illinois.

In a block of two-plant hills twenty were selected which contained plants of approximately equal size. On August 15, when the kernels were in the roasting-ear or milk stage, the ear from the north or west plant in each hill was harvested. The ear on the other stalk was allowed to mature before it was harvested. From another group of twenty twin-plant hills both the blade and the sheath were removed from the north or west stalk. (Fig. 1) The other plant in these hills was uninjured. Ears from both were left on the stalks until normal time of harvest. From another group of twenty selected hills the north or west plant was treated by removal of the blades only. The neighbor plant in each hill of this group served as an untreated check.

Each ear was harvested in mid-November and tagged separately so that the yield of the treated plants could be compared with that of the untreated checks in the same hill. The results are presented in Table 1.

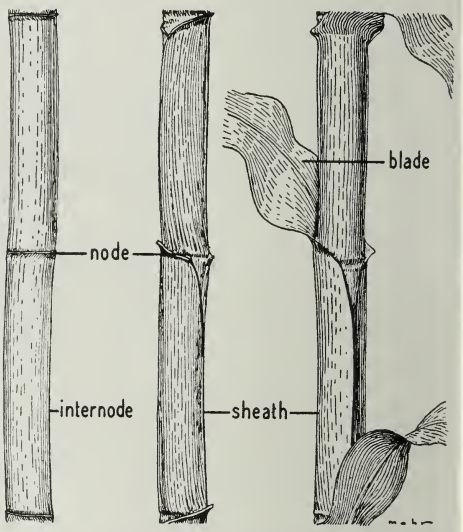

Fig. 1.—Stalks of corn illustrating both blades and sheaths removed (left); blades removed but sheath intact (center); and both blades and sheath intact (right). (Drawing by Dr. Carl Mohr).

Table 1.—Yields of Corn Plants Treated When the Kernels Were in the Milk Stage by (1) Harvesting Ears, (2) Removing Both Blades and Sheaths, and (3) Removing the Blades Only Compared With Normal Uninjured Plants. Urbana, 1941.

Treatment applied when kernels on the ears were in the milk stage	Yield per acre		Test weight per bushel	Weight of 1000 kernels
	Shelled corn	Cobs		
	bu.	lbs.	lbs.	gms.
Harvested ears	*19.7**	*690.8**	38.7	88.2
All blades and sheaths removed	*26.8*	*621.3*	45.8	104.0
All blades removed	*30.0*	*630.7*	47.9	126.1
None (normal, uninjured plants)	81.1	843.2	58.9	295.4

* Italicized data were accompanied by odds according to Student's method high enough to indicate distinct significance as compared with the untreated check.

Yield of shelled corn (Fig. 2) was lowest when the ears were harvested on the day the other plants were defoliated. This yield was about 7 bushels an acre lower than that obtained from plants having both blades and sheaths removed. The source of this greater yield may be in the photosynthesis by the chloroplasts in the green stalk, and in the translocation of reserve materials from the stalk and cob after the leaves were removed.

The yield of plants carrying leaf sheaths, but no blades, was a little over 3 bushels an acre more than that of plants from which both the sheaths and blades were cut away. This difference represents the photosynthetic activity of the sheaths. Taking off all blades at this stage of ear development lowered the yield 51 bushels an acre compared with plants on which the blades were allowed to remain.

The weight of cobs was about 70 pounds an acre greater when the ears were harvested in the milk stage than when all the blades and sheaths were removed at that stage. This indicates that the cobs of early harvested ears may have contained some grain-forming materials which, because of being removed from the stalk, were not translocated to the kernels.

Compared with ears harvested in the milk stage, ears left on stalks which were deprived of both blades and sheaths showed an increase in grain yield of 36 per cent, a decrease in cob weight of 10 per cent, an increase in bushel weight of 18 per cent, and an increase in weight of 1,000 kernels of 18 per cent. Leaving the ears on stalks from which the blades only were removed was associated with an increase in grain yield of 52 per cent, a decrease in cob weight of almost 9 per cent, and increase in weight per bushel and weight of 1,000 kernels of 24 and 43 per cent, respectively. Permitting the ears to remain on uninjured stalks until complete maturity increased the yield of shelled corn 312 per cent, the weight of cobs 22 per cent, the bushel weight 52 per cent, and the weight of 1,000 kernels 235 per cent.

Thus, the yield of shelled corn was made up of contributions as follows: 36 per cent from the green stalk alone, 17

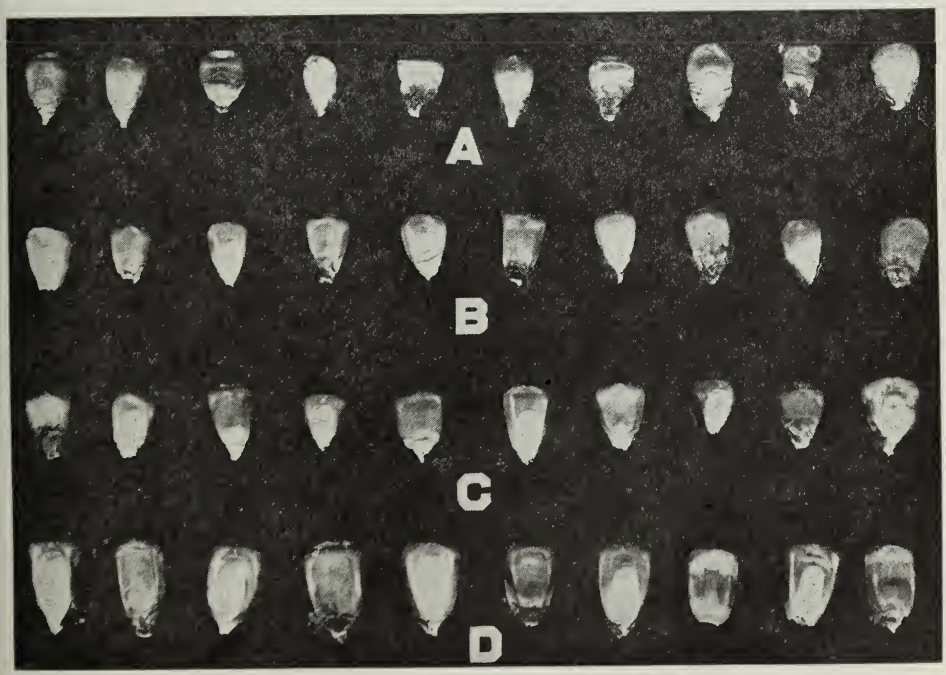

Fig. 2.—Representative kernels of maize produced by plants treated when the grain was in the milk stage by (A) harvesting the ears, (B) removing both blades and sheaths, (C) removing the blades, in comparison with (D) normal mature kernels produced on non-defoliated plants.

per cent from the leaf sheaths alone, and 259 per cent from the leaf blades alone. Considering only the development made after treatment, the bare stalk was responsible for 11.5 per cent, the leaf sheaths for 5.5 per cent, and the leaf blades for 83.0 per cent of the increase in yield of shelled corn.

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WAR PRODUCTION AND SOIL CONSERVATION IN ILLINOIS

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If "food will win the war and write the peace," as the Secretary of Agriculture has said, Illinois farmers have a very important part to play in accomplishing the desired result. Farmers are being asked to increase production, especially of animal products—milk, eggs, pork, lard, beef; vegetable oils — soybeans, peanuts, flax; and vegetables. The increases are needed both for domestic consumption and for use of the allies. Not only is Illinois an important livestock state, but is very important in both corn, the leading feed grain, and in soybean production.

Illinois crop acreage has been shifting from more erosion-causing crops to erosion-control or prevention crops since the AAA program came into existence. The accompanying table lists the important Illinois crop acreage for the 1930-32 period, 1941 and intended for 1942. Under the AAA program corn and small grain acreage decreased and hay and rotation pasture increased, up through 1941. Soybeans increased greatly during this period, partly because of the AAA program and partly as the natural development of this new crop. (See Table 1.)

The shift in crop acreage was accompanied by increased yields so that total production was maintained. This acreage shift, accomplished through the emphasis of the AAA, the Soil Conservation Service, and the teachings of the Agricultural Extension Service, was accompanied by increased use of limestone, contour farming, terracing and deep rooted legumes. Limestone use averaged 405,000 tons for the state for the period 1930-32, compared with 2,650,000 tons in 1941. Alfalfa hay increased from an average of 253,000 acres for the period 1930-32 to 583,000 acres in 1941. The sweet clover acreage increased from an average of 835,000 acres for 1930-32 to 1,243,000 acres in 1941. Illinois farm advisers reported that 66,000 acres were contour farmed and 30,000 acres were

Table 1.—Acreage of Important Crops in Illinois, 1930-32, 1941, and 1942 Intentions

Crop	1930-32	1941	1942 Intentions
Corn	9,603,000	7,645,000	8,027,000
Wheat	1,932,000	1,776,000	1,226,000
Oats	4,337,000	3,584,000	3,571,000
Barley	343,000	135,000	200,000
Soybeans alone	810,000	2,743,000	3,703,000
Tame Hay	2,554,000	2,698,000	2,750,000
Total	19,579,000	18,581,000	19,477,000
Corn and Soybeans	10,413,000	10,388,000	11,730,000
Small Grains	6,612,000	5,495,000	4,997,000

terraced in 1941. The use of phosphates increased greatly also. Erosion was definitely being checked, fertility was being improved and crop yields were increasing as a result of the shifts being made in Illinois farming.

Under the war production program goals have been set for 1942. Increases were asked for most crops and for all livestock and livestock products. Two important exceptions in 1942 were wheat and oats. The wheat supply was excessive and soybean increases were being asked for in place of part of the oat acreage.

Farmers' intentions in Illinois for 1942 (Table above) indicate that feed grains and wheat will be held pretty well in line with the goals set for them and the soybean acreage will exceed the goal. The combined acreage of corn and soybeans planned shows a 13 per cent increase above the 1941 harvested acreage while small grains indicate a 9% decrease due largely to the drastic decrease in wheat acreage. The wheat acreage decrease was partly due to weather conditions. The hay acreage is expected to be slightly larger than in 1941, but the rotation pasture is likely to decrease in favor of soybeans.

Legume seedings are not expected to increase in 1942 and it is very doubtful if limestone applications can be maintained at the level prevailing during 1940 and 1941. This shift in crop acreage for 1942 will undoubtedly increase production of the crops especially needed, as well as total production and will remove more soil fertility. Less soil conservation and improvement is likely to be practiced.

The period of war production will extend beyond 1942; in fact the period most often mentioned is five years. Thus production without seriously increasing soil erosion becomes a paramount problem. Both crop and livestock production must be and will be forthcoming. To the extent that the livestock is produced on the same farms as the feed that they consume, the soil conservation problem will be minimized, both because of the rotations followed and because of minimum loss of fertility where the manure is properly handled.

The goal of production is the greatest total production over the five year period. To secure this maximum production it will be necessary to use the soil to the utmost, but it will also be necessary to grow enough legumes and to carry on sufficient soil building practices so that the soil will continue to produce approximately as much as it has in the past.

Conservation is the key to securing maximum production. Conservation is "use without waste." To obtain this maximum production without serious waste the following suggestions are offered:

1. Farm the level, highly productive land harder rather than plow up the rougher, poorer land that would be subject to severe erosion when planted to a cultivated crop.
2. Seed all small grains to a legume.
3. Make sufficient seeding of legumes and grasses each year to assure an adequate supply of hay and pasture in the following year.
4. Contour clean-tilled and small grain crops on sloping land to increase yields and save soil and water.
5. Apply limestone, phosphate, and other fertilizers, where needed, to the maximum of availability and feasibility.
6. Make special effort to get barnyard manure out on fields where greatest return in production will result and refrain from wasteful burning of crop residues.
7. Leave wide grassed waterways in fields being broken out of sod, and establish new grass waterways in the natural drainageways in other fields.
8. Use terraces and strip farming where it appears desirable to cultivate land too steep to be handled satisfactorily with just contouring.
9. Plant soybeans on level land as far as possible. Where planted on sloping land, plant on the contour and follow with winter cover crop.
10. Adjust rotations in line with goals, and the physical and fertility characteristics of the soil.

Through maximum use of the above practices it should be possible to obtain the production being asked for without serious permanent depletion of the soil during the war period.

USING THE SLOPE MAP AS A BASIS FOR FARM PLANNING

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The almost universal pattern for laying out farms into fields has been that of a number of equal sized fields of rectangular or square shape. The fact that the topography of the field many times varied from level to slopes of as much as 15 per cent did not receive much consideration in planning for fence lines. Fields which were made up of various degrees of slope, usually could not be farmed so as to get a good profit from the soil and at the same time not lose the top soil by erosion. In making a good farm plan one should consider the capacity of the land to produce and still remain in place and maintain or improve in fertility. As a basis for a good farm plan the slope map provides information on field arrangement and selection of crops, as the greater the slope in length or per cent, or both, the greater the erosion hazard and the more crop protection necessary. The slope of the land gives a good indication of the amount of surface soil remaining or the amount that will be remaining if ordinary farm arrangement is continued.

The slope map of a farm is made by reading the slope of an area with a level such as the Abney Hand Level and sketching the area on a map of the farm. Usually 5 or 6 classes of slope are used, these being: Level (0 through 1 per cent), Gently rolling (2 through 4 per cent), Rolling (5 through 9 per cent), Rough (10 through 14 per cent) and Hilly (15 per cent or above). Each of the above classes is given a color and all of the like slopes are colored on the map in one color. Field arrangement is then made up to include like areas in the same system or rotation. The field arrangement can easily be determined by placing an outline map of the farm over the colored map and sketching in field lines. Fences will not always divide a farm into four equal and uniform shape and size fields, but they can be placed so that a series of uniform size fields with uniform topography can be included in one rotation.

The level land will stand a rotation with more cultivated crops and less meadow than will the next class in steepness. Likewise the level land will need less protection from mechanical measures such as terraces, contour farming and grass waterways than will the next class with greater slope.

Using Slope Map.—If such mechanical measures are used then a stronger rotation can be used on the areas with more slope. To illustrate, consider the field of 3% slope which without any protection would need to be served by a rotation such as, Corn, Small Grain, Meadow, Meadow. The same field, if contour farmed could stand to have a rotation with one more year of corn, or perhaps one year less of meadow.

The shape of fields can be planned so that the rows of crops can be on the level and not up and down the slope. Many times this can be accomplished by only moving one fence to run at right angles to the old line. In other cases fences may be on a curve or diagonal. In many cases long slopes can be divided by fences or strips of crops so that accumulation of large volume of water is hindered as much as possible.

Areas that are too steep can be arranged for pasture while those which are not convenient for pasture or are too steep for grazing can be set aside for tree plantings.

Using the slope map as a basis for planning and supplementing it with other points for consideration in planning make possible a plan which will make fullest use of the capability of the land and protect it from erosion. Without consideration of the slope of the land much needless waste of the top soil and surface water takes place. Certainly both the surface water and surface soil must be controlled if maximum production is to be secured. That slope map gives a sound basis for planning a farm so as to conserve soil and water.

EDUCATION FOR OUT OF SCHOOL RURAL YOUTH

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Do rural young people who are now out of school get much further education other than the training that comes from experience? To what extent do they drop out of school before finishing high school or college? Do they want to continue their education? If they had the chance for further education, what would they want? These are questions a recent Randolph county rural youth study carried on by the Agricultural Experiment Station in cooperation with the U. S. Department of Agriculture, Division of Farm Population and Rural Welfare and the county farm adviser, the Randolph County Rural Youth Group, and AAA committeemen in the county, sought to answer in January, 1941. The study included: years of school, extent of vocational education, and additional training desired. The data were secured from 1,040 farm and nonfarm rural youth, age 18 to 30 years.

Extended Schooling.—The first question naturally asked is, when do these rural youth drop out of school? In Randolph county almost two-thirds of the young men and over one-half of the young women dropped out after finishing the eighth grade. One in five of the young men and one in four of the young women finished high school, but only one in twelve of the young women and less than 2 per cent of the young men went on to college.

Why do such a large number of rural youth drop out of school after finishing the eighth grade? There may be several reasons: Young men feel that they need to get started in farming. Both young men and young women feel that high schools offer them little in the field in which they are interested. The parents of these rural youth may need them at home. They may feel they cannot afford to go on to school, or they may feel that they cannot keep up in dress, manner, or studies with those in high school. Farm young women, especially, may have been led to feel that an eighth grade education was enough for them.

Doubtless, many of those who went on to high school wished to do something other than farming. This is especially true of the young women. Most of the rural youth who went on to college went for a period of only two years and obviously were preparing to become teachers or to get a business college training.

Vocational Training.—Opportunities in vocational training are limited in Randolph county to agricultural departments in the high schools of Chester and Sparta; home economics is offered in Sparta, Chester, and Red Bud. Of a total of 615 rural young men only one in twelve had taken any vocational training. One in 25 had vocational agriculture and one in 50 had taken a business course. More than nine out of ten young men in the county depended upon experience and training other than in school to fit them for the vocation of farming.

One out of six of 427 rural young women took some form of vocational training. About half of these took a business course; less than one in twenty took home economics. Of those going to high school, one in three had some business, home economics, or teacher training. Evidently most of them were looking toward nonfarm occupations. The majority of the girls who went on to farms had no public school vocational training, yet most of them went into the vocation of home making.

Additional Training Desired. — More than half of the out-of-school rural young men in Randolph county wanted additional vocational training. Over one-fourth wanted additional training in semi-skill vocations, one-sixth in agriculture, and one in twenty in the professions. Only one-third of the out-of-school rural young women wanted additional training; half of these wanted it in home economics, about one in twenty wanted clerical training, and about one in twenty wanted professional training.

Though half of the out-of-school rural young men in Randolph county expressed a desire for additional vocational training only one in twelve was getting it. If a program of training work develops, it doubtless should include both agriculture and the semi-skilled trades. About half of the young women wanting additional vocational training seem to be getting it. Additional training opportunities should, therefore, include training in home economics and training for clerical and professional work.

Expansion in classes and other opportunities for additional training for out-of-school rural youth, should evidently come in the fields relating to agriculture, home economics, semi-skilled trades, clerical occupations and the professions. Efforts to expand the program should recognize the need for coordination of extension work, vocational agriculture, home economics, and other efforts to offer out-of-school training for rural youth so that the program could be developed on a unified basis in the county. This is especially desirable in view of the war needs, and the movement of a large number of rural youth out of the country into the army and into war industries. It will be equally valuable when the war is over, and when the rural youth begin to come back into the county to find jobs. A unified guidance and training program should, and can, be developed for rural youth in Illinois. It will require coordinating the effort of all of those who are now working in the field of training of youth for rural life.

PAPERS IN ANTHROPOLOGY

FROM THE REPORT OF THE SECTION CHAIRMAN

This section carried 6 papers, 2 of which, including one abstract, are herewith published, plus one from the Collegiate Section. Titles and authors of the four papers not published are as follows:

BARLOGA, F. L., Peoria, Illinois, *Indian trail markers.*

GRIFFIN, J. W., Daytona Beach, Fla., *Tree ring dating in the Middle West.*

LINK, GEORGE M., *Report on the Archaeology of Pere Marquette State Park.*

WRAY, D. E., Peoria, Illinois, *Analysis of archaeological sites.*

Fifty persons attended the meeting and elected Ben Nussbaum, Fairbury, Illinois, chairman for the 1942-43 meeting at Jacksonville.

(Signed) DONALD E. WRAY, *Chairman*

ARCHAEOLOGICAL HORIZONS IN SOUTHERN ILLINOIS

JOHN W. BENNETT AND MOREAU MAXWELL

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Abstract

In the past 5 years excavations by the University of Chicago, in Massac County, the Carbondale State Normal in Jackson County, and of the St. Louis Academy of Science in the St. Louis region, have been centered upon the problem of north-south transitional cultures. This work has shown a number of interlocking culture sequences that has assisted in redefining the significance of the Fulton County sequences, established by Cole and Deuel. The general periods into which this material falls will be discussed briefly:

Non-Pottery Period.—This horizon is represented by artifacts found in the lowest levels of the sites excavated by Moreau Maxwell for Southern Illinois Normal University. It is also represented at the Kincaid site in Massac County. In these two areas the material is related to the shell-mound cultures of the Southeastern United States. Robert Adams, excavating for the St. Louis group, has also found a pre-pottery level, but it is probably unrelated to the others. **Early Woodland Period.**—This period is represented by heavy, grit-tempered, cord-marked or plain pottery at Carbondale and St. Louis. The material occurs in the lowest levels of the sites with cultures typical of the Middle Woodland period. Artifacts seem to be crude Woodland forms. **Middle Woodland Period.**—In this horizon a number of different cultures developed. At Kincaid two Southeastern cultures seemed to represent the northwestern end of a culture development in the Tennessee Valley. One of these (Baumer) featured fabric-impressed, limestone-tempered pottery; the other (Lewis) had clay-grit tempered, cordmarked pottery. At Carbondale a similar sequence occurred, only in this area the Baumer material received an intrusive influence of Illinois Hopewellian from the north. In the St. Louis area some of the Early Woodland cultures continued. These various cultures also had semi-permanent log-post houses, elaborate Woodland stone tools, and some bone artifacts.

In Fulton County this period was represented by Hopewellian and Central Basin. Black Sand and Red Ocher may belong to the preceding period, but also continued into Middle Woodland. **Classic Middle Mississippi.**—All areas received strong overlays of this culture. At Kincaid, the period was represented by a large Mississippi manifestation of a Southeastern type; at St. Louis the "Old Village" type of Cahokia culture flourished. "Trappist" or "Bean Pot" type of Cahokia material probably began developing in this period. **Late Middle Mississippi — Late Woodland Period.**—Trappist cultures continued, and spread all over central and southern Illinois. In some areas, as at the Crable Site in Fulton, strong influences from Oneota cultures (Siouian) were noticeable. A Late Woodland culture (Tampico) received Middle Mississippi influence. At Carbondale a local development of Late Woodland (Dillinger) shows a continuity from the earlier Middle Woodland cultures.

General Remarks.—The Korando Site, in Jackson County, occupies a special place inasmuch as it is contemporaneous with the Middle Woodland period and probably extends through to Late Woodland times. In this period its clay-tempered pottery appears in a Trappist culture (Plattin) in the St. Louis area. Korando is the northern frontier of a clay-tempered pottery horizon in the central and lower Mississippi Valley. It provides a link between the early and late horizons in Illinois.

The basically Southeastern cultures are more or less "pure" at Kincaid; at Carbondale they become mixed with northern facies; at St. Louis the Southeastern sequence can still be recognized, but it has become heavily modified by indigenous northern cultures. Farther north, in Fulton County, the typical central Illinois sequences appear.

THE PROBLEM OF PRIMITIVE EDUCATION WITH PARTICULAR REFERENCE TO THE IBO OF NIGERIA*

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Many definitions have been given to the word "education" by deans of psychology and education. Underlying all these definitions, there is an admission that education is what remains after all the Geometry, Latin, or Biology that has been learned is taken away. In other words, education is the process of orienting the child to the full utilization of his culture. Whether it has led him up into the fullest, noblest and most fruitful relationship with the world in which he finds himself, and thus has fitted him for the struggle of life is the significant consideration for education.

We are not, however, concerned with "education" in terms of schools, colleges and universities. Our chief interest in this paper is: How did the native African in general and the Ibo in particular get his education and what kind of education did he get? To answer this query we must first make sure of the psychology behind the primitive form of education. It was an attempt of the adults to guide the future generation into the behavior patterns and value systems into which they themselves had been led. In other words, primitive African education is a legacy handed down from one generation to the next so that the practices and items of knowledge that were current during the great ancestors' life-time might continue in forms as near as possible to the ancient customs and usages.

In strict parallel to the modern theory which states that education starts at birth, the education of the Ibo child starts at birth. In Iboland there is a ceremony immediately after the birth of a child. This ceremony known as Maa-Maa consists of a chant by a group of men, women and children:

> Child when you grow up be a good man—Maa maa
> When you are a man have sense, have tact—Maa maa
> When you are a man tell mother to buy you a hoe—Maa maa
> Then start to go to farm and work out yams—Maa maa
> Mother tells you word, hear [= obey]
> Father tells you word, hear [= obey]

And in modern times such lines as the following have been incorporated:

> When you grow up ask mother to buy you slate—Maa maa
> That you may learn book and work out money—Maa maa

The native belief is that the foregoing makes an impression on the undeveloped mind of the new-born child. The modern educational psychologist would, however, be relieved of his anxiety on hearing of such a wasted lesson period by reflecting on the fact that the grown-up children who joined in the ceremony were enabled to hear for themselves what took place at their own Maa-maa ceremony.

For a long time the child receives no direct instructions as to his behavior. But his presence in the family as a new-born child affords the material for the instruction of others. For example, the grown-up girls, who expect to be mothers some day, are given object lessons in the nursing and care of their own babies when they have them.

Later, when the child is eight days old, the naming ceremony furnishes the setting for a historical survey of the family. Every Ibo name has a meaning and the meaning either summarizes the historical background of the child's family or the circumstances of his birth or the hope of what the child will be. The review of family history included in these rites has an obvious effect on the half-grown children who are present.

As we can see, then, the social significance of Ibo names is of considerable importance in the process of education. Names of outstanding warriors are given to children in order to immortalize the

* Contribution from the Collegiate Section.

achievements of great generals and fighters and also to provide suitable standards for the children to emulate. We say: "Agua onye afa chi ya analu"—If we give a name to a child, his god accepts it. This implies that the child will be expected to have supernatural aid in living up to the standards set by the great man whose name he bears.

The child's whole philosophy of life may be tempered by his knowledge of family feuds and injustices which are revealed in the names of the other children of the polygymous household to which he belongs.

I shall now consider the first step mentioned: Nursing. The Ibo give no solid or nourishing food for the first three days. During this time the baby is given only water. Because the mother's milk is unfit for the child's use at this time, treatment is given to make the milk healthy and useable. The child is nursed at 6 a. m., again at 9 a. m. or 10 a. m., and at equal intervals throughout the day and when it cries. A young maiden who may be privileged to study infant nursing observes in minutest detail the whole procedure of nursing. She is free to ask questions but is regarded as a "dunce" if she asks questions on points she should have observed herself. After an apprenticeship of about three months the young girl takes over the bathing and care of the child.

As soon as the child is able to go about and to play with other children, the mother's duty is to find out the type of children the child plays with. Sometimes the child is commanded to keep away from a particular boy who may be known to be dishonest or disrespectful to elders. In the ubiquitous mud pie plays, children symbolically express what they have seen the older folks do in ordinary life.

Until the child is about eight years old, his credulity is much exploited. It should be explained that, in Iboland, the water supply for drinking and domestic purposes is stored in earthen pots. These are usually placed in a cool corner of the house. On the cover of the pot in which drinking water has been stored are to be seen as many as three to five cups, all turned upside down. Should the child form a habit of leaving the cups unturned after drinking, the mother orders him to turn over the cup. Otherwise, he is told, he will expose himself to the ghost who drinks from any cup that is left unturned. The child obeys, not knowing that the real purpose is to prevent dirt or ants from falling into the cup and ultimately into the pot.

Proper meal-time manners are strictly inculcated. Washing of h a n d s before meals is compulsory. The rule is: Wash your hands and eat, or do not wash your hands and do not eat. The child is told that if he sits down for a meal and leans to one side with one hand on the floor, the earth will eat all the food through the hand on which he leans and he will remain hungry. He is also told that if he hurries over his meal he will be caught by a ghost in the latrine. The above methods do succeed in inculcating correct hygienic practices.

As for personal hygiene, the child is helped to wash or bathe himself. This assistance is only meant to help the child to know to what parts of his body he should devote more time. A schedule of two baths a day is a pleasure to the child. The underlying reason is apparent when we take into consideration the climate of his homeland. From about the age of nine no child expects an elder to help him keep his body clean.

In addition to the foregoing methods of education the child depends on his personal observations. From the age of about nine, the male child accompanies his father to the farm, while the girl accompanies her mother to the market. The girl from this time on acquaints herself with domestic duties and the boy learns farm-craft by observing w h a t others do on his father's farm. On the farm the boy's father teaches him the rudiments of agriculture.

In the market the girl is taught the intricacies of buying and selling. The child notices that her mother at the outset of any bargain will quote a price almost double what she has paid for her commodity she is about to sell to a customer. The customer in turn offers a price just a little below the cost price. The seller herself then makes a little reduction from her first price. The customer is thus tempted to offer a new price, this time well above the cost price. Further inducements are tried in an attempt to persuade the customer to offer more, and sometimes these are effective. After the encounter has ended the girl will probably fire a barrage of questions

concerning problems in trade. These questions are carefully answered and gradually the girl is allowed to attempt independent ventures.

In addition to individual training given by parents, training in folklore and good citizenship is given by the different secret societies and age group organizations. Most of the boys clubs are organized on a basis similar to the Boy Scout organization. The "Mbekwe" club, for example, meets at regular intervals to enjoy communal meals and to limelight each member's activities. This club prepares the boys for more advanced secret societies. "Respect of womanhood" is the motto of the club.

One culture trait that has contributed much to Ibo education is the lavish use of folk-literature—tales, proverbs, and riddles. Proverbs are used not only to point morals for young and old alike, but as signals or warnings against proposed actions. Children of about five to eight years of age who have been learning how to count by naming the constellations in rhymes and jingles will also be plied with brain teasers—riddles—before an old man tells a folk-tale to wind up an evening. Most of the tales are ornamented with folk-songs and dance-songs. At the end of the tale a free discussion generally follows on what each hearer could have done if he had been placed in some of the situations encountered by the hero of the tale.

I have defined education as that process which operates to bring the individual to the fullest, noblest and most fruitful relationship with the world in which he lives. In modern American culture economic and social specialization and complexity have necessitated an educational system which is equally specialized and complex. In order to implement this kind of educational system, unusually elaborate institutions have developed. Because of pre-occupation with these specialized educational institutions, European and American educators have been forced to ignore or de-emphasize certain underlying educational processes which go on in all cultures, primitive or non-primitive.

Ibo culture, which incidentally is far from the stereotype of so-called primitive simplicity, has felt no need until recently for the erection of an educational superstructure of grammar-schools, high-schools and colleges on the European pattern. These became necessary only when the Ibo found that he had to compete with the European on the European's own terms. As I have indicated in this paper Ibo education has been focused primarily on the fundamental problem of orienting the child in his culture.

In the main the Ibo (and to a certain extent the "primitive") system of education emphasizes just those phases of child-rearing which are left in Western culture to more or less haphazard conditioning by parents and playmates. It is, despite this difference in emphasis, none the less an efficiently functioning system of education.

ADDITIONAL CLEAR LAKE VILLAGE MATERIAL

E. Schoenbeck

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Clear Lake village, in Tazewell and Mason counties, originally excavated and described by Drs. Faye-Cooper Cole and Thorne Deuel,[1] has yielded through the later excavations of G. and E. Schoenbeck and A. Simpson, members of the Peoria Academy of Science, a wealth of material and considerable data which contributes to a better understanding of both this site and the inclusive Hopewell in this area.

Excavations of the year May 1941-May 1942 have greatly increased amounts of objects and widened the range. The relative position and abundance of the Hopewellian and the Maples Mills representations continue with the Hopewellian, the lower and the richer. A meager Mississippian representation occurs in higher depth. Objects of interest are a skull of Bison bison;[2] 3 pipes (none platform); a copper pin; a clamshell carved to show a face in profile; new pottery types and type variations; additional shell hoes associated with Hopewellian material; and a cache of three 12 to 17#, shaped, grooved, stone artifacts which are perhaps anchors, but suggested as possibly mullers used with a sweep.

The highly developed pottery complex grows increasingly richer. Pottery totals are now: rims, 2,000; vessel portions sufficient for projection, 48; Woodland and Hopewellian shapes, 13, and Mississippian, 3. A ceramic analysis by Dr. James B. Griffin, Curator, Ceramic Repository, University of Michigan, lists: **Woodland.**—Gooden Cord Impressed, Woodland Plain, Woodland Cordmarked, Sister Creeks Punctated, Various simple incised sherds, Black Sands Incised, Cord-Wrapped stick stamp, Naples Stamped, Havana Zoned Stamped or Incised, Hopewell Zoned Stamp, Hopewell Zoned Incised, Hopewell Rim Incised, Fabric Impressed, Check Stamp (the first record in Illinois). **Foreign.**—1. typical of Missouri Woodland; 2. suggesting importation from Florida coast area. **Mississippi.**—St. Clair Plain.

In much of the Cord Impressed ware is used a black angular tempering of basaltic hornblende,[3] possibly analogous to that described for Lake Michigan ware at Aztalan,[4] and to that of Adena ware. Added shapes in Lake Michigan phase ware are a cord-decorated sloping-necked jar and a collared olla.

Fig. 1.—Bison skull, jaw, scapula and other bone excavated at Clear Lake village, by E. Schoenbeck. Nov. 11, 1941. Jaw and other bone are behind skull; beaver skull to one side. Scapula had lain on top of skull, between horns.

The Bison skull, thought to be the first reported from archaeological sites east of the Mississippi river, lay in upper depth in discolored sand, in association with a Maples Mills sherd, a beaver skull, other bones of bison, deer and turtle. Horn cores appear as rotten particles held together by sand. Other bone items are a 10-inch, grooved awl; a fishhook; skulls of infant and various animals; and unidentified artifacts. Clamshell objects include a cache of 7 spoons, a cache of 7 shells showing use as diggers, and shells with perforations and cutouts.

Stone items are a reel-shaped gorget, a symmetrical concretion polished by handling; a discoidal from upper depth; and 2 stone pipes, one stemmed, one stemless, both associated with Hopewellian material, suggesting existence in some areas of various types for casual use. The third pipe is an incised clay elbow.

[1] *Rediscovering Illinois*, University of Chicago publication, 1937.
[2] Identification by photographs and measurements by Dr. M. W. Stirling, Chief, Bureau of American Ethnology, Smithsonial Institution, and Dr. Olson, Department of Paleontology, University of Chicago.
[3] Identification by Dr. F. R. Matson, University of Michigan.
[4] *Ancient Aztalan*, p. 303, Bulletin, Public Museum, Milwaukee, 1933.

PAPERS IN BOTANY

FROM THE REPORT OF THE SECTION CHAIRMAN

The Botany program at Urbana carried 18 papers, 15 of which are herewith published. The others were:

JENSEN, JENS, Ellison Bay, Wisconsin, *Plant sanctuaria.*

O'HANLON, SISTER MARY ELLEN, Rosary College, River Forest, Illinois, *Leaves in ontogeny and phylogeny.*

VESTAL, A. G., University of Illinois, Urbana, Illinois, *Island groves in Illinois prairies.*

In addition to these, one of the papers submitted from the Collegiate Section was accepted for publication, and is herewith published.

Seventy-five attended the meeting and K. Richard Johnson, National College of Education, Evanston, Illinois, was elected chairman for the Jacksonville meeting May 7-8, 1943.

(Signed) J. FISHER STANFIELD, *Chairman*

NOTES ON THE DISTRIBUTION OF SOME RARELY REPORTED SPECIES OF OEDOGONIUM

M. E. Britton

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Studies of Illinois waters by several investigators have resulted in reports of between seven and eight hundred species of algae. Of these the single genus Oedogonium is represented by seventy-nine species, varieties, and forms (Tiffany 1937, 1939) or roughly twenty-eight per cent of the two hundred and eighty-three species reported in the literature as occurring in North America.

In the course of recent studies of Illinois and Indiana algae, the writer has collected seven additional records of species of Oedogonium, which by their rarity of occurrence merit mention at this time. Two of these were orginally described from North American material and have not been reported from localities other than that of the type. The five remaining species were described from type localities in Africa, Estonia, Germany and Sweden, and only two have been previously recorded for North America. The species to be reported are as follows:

Oedogonium acmandrium var. *stictospermum* Skuja, Acta Horti Univ. Latv. 4: 30(1930); Tiffany, N. Am. Fl. 11(1): 84(1937).

Collected from a small swamp and intermittent pond on Central Road about two miles west of Glenview, Cook County, Illinois, May 12, 1938. Author's Herb. #56.

Previously known only from the type station on the island of Saaremaa (Ezel), Estonia.

Oedogonium concatenatum var. *superornatum* Tiffany, N. Am. Fl. 11(1): 64 (1937).

Collected from small swamps, ponds and intermittent streams on Glenview Road about two miles west of Glenview, on Lake Avenue just east of Pfingsten Road, on Landwehr Road one-half mile north of Lake Avenue, and on Pfingsten Road about one mile north of Lake Avenue, Glenview, Cook County, Illinois, May 12, 1938; on Techny Road just east and west of Landwehr Road southwest of Northbrook, Cook County, Illinois, May 12, 1938; small pond just east of Telegraph Road about one mile south of Everett, Lake County, Illinois, May 15, 1938. Author's Herb. #58-60, 62-64, 71.

Previously known only from the type station at Woods Hole, Massachusetts.

Oedogonium Croasdaleae Jao, Rhodora 36: 202(1934); Tiffany, N. Am. Fl. 11(1): 69. Pl. 26. f. 416-419(1937).

Collected from small swamps and intermittent ponds on Central Road about two miles west of Glenview, Cook County, Illinois, May 12, 1938; swamp north of Rolling Prairie, La Porte County, and a small pond north of Valparaiso, Porter County, Indiana, April 30, 1938. Author's Herb. #31, 37, 53, 56.

Previously known only from the type station at Woods Hole, Massachusetts.

Oedogonium decipiens var. *africanum* Tiffany, Ohio Jour. Sci. 29: 74(1929); Oedog. Monog. p. 145. Pl. 55. f. 523-524(1930).

Collected in swamp and intermittent pond in Somme Forest Preserve, Northbrook, Cook County, Illinois, May 15, 1938. Author's Herb. #66.

Previously known only from the type station in Angola, Africa, and from Indiana.

Oedogonium fragile var. *abyssinicum* Hirn, Acta Soc. Sci. Fennicae 27: 97(1900); Tiffany, Oedog. Monog. p. 75. Pl. 15. f. 147(1930).

Collected in swamps and intermittent ponds on Techny Road just east of Landwehr Road, Northbrook, and on Landwehr Road about one-half mile north of Lake Avenue, Glenview, Cook County, Illinois, May 12, 1938; swamp and intermittent pond in Somme Forest Preserve, Northbrook, Cook County, Illinois, May 15, 1938; swamp north of Valparaiso, Porter County, Indiana, April 30, 1938. Author's Herb. #36, 60, 62, 66.

Previously known only from the type station in Africa.

Oedogonium Kirchneri Wittrock, Hedwigia 21: 104(1882); Tiffany, Oedog. Monog. p. 116. Pl. 38. f. 371(1930).

Collected in a small pond on Techny Road just west of Landwehr Road and in a swamp and intermittent pond in the Somme Forest Preserve, Northbrook, Cook County, Illinois, May 12 and 15, 1938. Author's Herb. #63, 66.

Previously known only from the type station in Germany.

Oedogonium nodulosum Wittrock, Bih. Sv. Vet.-Akad. Handl. 11: 22(1872); Tiffany, N. Am. Fl. 11(1): 74. Pl. 23. f. 370-371(1937).

Collected in a swamp north of Rolling Prairie, La Porte County, Indiana, April 30, 1938. Author's Herb. #32.

Previously known only from the type station in Sweden and from Michigan.

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A PENICILLIUM "DISEASE" OF INK

Robert A. Conover and Neil E. Stevens

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The damaged soap wrappers on which the present study is based were sent to us by Mr. R. H. Griffith of the In-Tag Company who has given us permission to publish our findings.

The blemishes consisted of pale reddish-brown spots which had developed in storage on the blue portions of the wrappers of a well known white soap. The spots were regular in outline, of varying size, and occurred only on the blue portion of the wrappers. The reddish areas did not extend through the thickness of the paper but were restricted to the fibers covered by the ink. Cultures from the discolored fibers resulted uniformily in the isolation of a species of Penicillium not yet positively identified.

The fungus was cultured on a wide variety of media on all of which growth was very slow. At the end of one month at room temperatures, colonies never exceeded an inch and were usually one-half inch in diameter.

Samples of the dye, ultra-marine blue, and ink used in printing the wrappers were supplied by Mr. Griffith. The dye dispersed in the various media was decolorized by the growth of the fungus. This is in all probability due to the change in the pH of the medium resulting from the growth of the fungus. The dye is sensitive to acids and loses its blue color as the pH is lowered. The fungus was cultured in a liquid medium which contained KH_2PO_4 0.3g., $MgSO_4$ 0.25g., KNO_3 2.0g., dextrose 30.0g., and water to make a liter and determinations of the pH were made at various intervals. At the end of two weeks the pH was lowered from 5 to 3.8 and further lowered to 3.2 after four weeks growth.

The ink, smeared over the surface of agar and on strips of filter paper laid over the agar, was changed to a pale reddish-brown color closely matching that on the wrappers when the fungus was cultured beside it. Other fungi present as contaminants in some cultures failed to cause the color change. Attempts to produce the reddish color found on the wrappers on plain filter paper were unsuccessful. That the reaction involved in causing the reddish spots may be more complex than an acid-base reaction is indicated by the fact that the fungus when grown in contact with the dye alone will not produce the reddish color. Some constituent of the ink other than the dye apparently must be present in order to obtain the color found on the affected soap wrappers.

TREES AND SHRUBS OF CHAMPAIGN COUNTY, ILLINOIS

ALBERT W. FELDMAN

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The terms trees and shrubs as used here include those plants that are all or part woody. Size is the usual means of distinguishing a tree from a shrub; the line of demarcation is, however, arbitrary and often difficult to follow. In the following list there are 130 native and naturalized species of woody plants; of these 64 are trees, 51 shrubs and woody climbers, 2 suffrutescent, and 13 classified as either trees or shrubs.

The sequence of families, and the nomenclature, are those of Rehder's "Manual of Cultivated Trees and Shrubs," (ed. 2) 1940. Most of the common names have been adapted from Deam's "Flora of Indiana." The selection of a vernacular name from the multitude of those in use is quite difficult, especially since the same name is often applied to several totally different plants. All specimens upon which this study is based are in the Herbarium of the University of Illinois. The name of each species is followed by a letter or combination of letters to indicate its habit of growth as, Shrub (S), Tree (T), Vine (V), and Suffrutescent (Su).

I should like to express my appreciation to Dr. G. N. Jones for his assistance and criticism of this work.

Pinaceae
- Juniperus virginiana L. Red cedar (S or T)

Salicaceae
- Populus alba L. White poplar (T)
- P. canescens (Ait.) Sm. Gray poplar (T)
- P. deltoides Marsh. Cottonwood (T)
- P. grandidentata Michx. Largetooth aspen (T)
- Salix alba L. European white willow (T)
- S. cordata Muhl. Hearthleaf willow (S)
- S. fragilis L. Brittle willow (T)
- S. interior Rowlee. Longleaf willow (S)
- S. nigra Marsh. Black willow (T)
- S. pentandra L. Bayleaf willow (T)
- S. prinoides Pursh. (S)
- S. vitellina L. Golden willow (T)

Juglandaceae
- Juglans nigra L. Black walnut (T)
- Carya cordiformis (Wang.) K.Kock Bitternut hickory (T)
- C. glabra (Mill.) Sweet Pignut hickory (T)
- C. laciniosa (Michx.f.) Loud. Bigleaf shagbark hickory (T)
- C. ovalis (Wang.) Sarg. Small fruited hickory (T)
- C. ovata (Mill.) K.Koch Shagbark hickory (T)

Betulaceae
- Carpinus caroliniana Walt. Blue beech (T)
- Corylus americana Walt. American hazelnut (S)
- Ostrya virginiana (Mill.) K.Koch Hop hornbeam (T)

Fagaceae
- Quercus alba L. White oak (T)
- Q. bicolor Willd. Swamp white oak (T)
- Q. coccinea Muench. Scarlet oak (T)
- Q. imbricaria Michx. Shingle oak (T)
- Q. macrocarpa Michx. Bur oak (T)
- Q. maxima (Marsh.) Ashe Red oak (T)
- Q. muhlenbergii Engelm. Chinquapin oak (T)
- Q. palustris Muench. Pin oak (T)
- XQ. runcinata Engelm. (Q. imbricaria X maxima) (T)
- Q. velutina Lam. Black oak (T)

Ulmaceae
- Celtis occidentalis L. Hackberry (T)
- Ulmus americana L. American elm (T)
- U. fulva Michx. Slippery elm (T)

Moraceae
- Morus alba L. White mulberry (T)
- M. rubra L. Red mulberry (T)
- Maclura pomifera (Raf.) Schneider Osage orange (T)

Ranunculaceae
- Clematis pitcheri T. & G. Pitcher leather flower (V)
- C. virginiana L. Virgins bower (V)

Menispermaceae
- Menispermum canadense L. Common moonseed (V)

Anonaceae
- Asimina triloba (L.) Dunal. Pawpaw (T)

Lauraceae
- Sassafras albidum (Nutt.) Nees. Sassafras (T)
- Lindera benzoin (L.) Bl. Spicebush (S)

Grossulariaceae
- Ribes americana Mill. American black current (S)
- R. missouriensis Nutt. Missouri gooseberry (S)

Platanaceae
- Platanus occidentalis L. American planetree (T)

Rosaceae
- Amelanchier canadensis (L.) Medic. Downy shadblow (T)
- Crataegus crus-galli L. Cockspur thorn (S. or T)
- C. macracantha Lodd. (S or T)
- C. mollis (T. & G.) Scheele (T)
- C. pedicellata Sarg. (T)
- C. pruinosa (Wendl.) K.Koch (S or T)
- Malus angustifolia (Ait.) Michx. (S or T)
- M. coronaria (L.) Mill. Wild sweet crab (T)

M. ioensis (Wood) Britt. Prairie crab (T)
Prunus americana Marsh. American plum (T)
P. angustifolia Marsh. Chickasaw plum (S or T)
P. hortulana Bailey Hortulan plum (T)
P. serotina Ehrh. Black cherry (T)
P. virginiana L. Common chokecherry (S or T)
Rosa carolina L. Pasture rose (S)
R. rubiginosa L. (S)
R. setigera Michx. Prairie rose (S)
R. suffulta Greene (S)
Rubus allegheniensis Porter. Allegheny blackberry (S)
R. argutus Link Highbush blackberry (S)
R. flagellaris Willd. Northern dewberry (S)
R. occidentalis L. Common blackcap raspberry (S)
Spiraea alba DuRoi Meadow spirea (S)

Leguminosae
Amorpha canescens Nutt. Lead plant (Su)
A. fruticosa L. Indigobush (S)
Cercis canadensis L. Redbud (T)
Gleditsia triacanthos L. Honey locust (T)
Gymnocladus dioica (L.) K.Koch Kentucky coffeetree (T)
Robinia pseudo-acacia L. Black locust (T)

Simarubaceae
Ailanthus altissima (Mill.) Swingle Ailanthus (T)

Rutaceae
Zanthoxylum americanum Mill. Northern prickly ash (T)
Ptelea trifoliata L. Common hoptree (T)

Anacardiaceae
Rhus aromatica Ait. Fragrant sumac (S)
R. glabra L. Smooth sumac (S)
R. radicans L. Poison ivy (V)

Celastraceae
Evonymus atropurpureus Jacq. Wahoo (S or T)
E. obovata Nutt. Running evonymus (S)
Celastrus scandens L. American bittersweet (V)

Staphyleaceae
Staphylea trifolia L. American bladdernut (S)

Aceraceae
Acer negundo L. Box elder (T)
A. nigrum Michx.f. Black maple (T)
A. rubrum L. Red maple (T)
A. saccharinum L. Silver maple (T)
A. saccharum Marsh. Sugar maple (T)

Sapindaceae
Aesculus glabra Willd. Ohio buckeye (T)

Rhamnaceae
Ceanothus americanus L. New Jersey tea (S)
Rhamnus frangula L. Glossy buckthorn (S or T)
R. lanceolata Pursh. Lanceleaf buckthorn (S)

Vitaceae
Parthenocissus quinquefolia (L.) Planch. Virginia creeper (V)
P. vitacea (Knerr) Hitchc. (V)
Vitis aestivalis Michx. Summer grape (V)
V. cinerea Engelm. Sweet winter grape (V)
V. labrusca L. Fox grape (V)
V. palmata Vahl. Catbird grape (V)
V. riparia Michx. Riverbank grape (V)
V. vulpina L. Frost grape (V)

Tiliaceae
Tilia americana L. American linden (T)

Hypericaceae
Hypericum sphaerocarpum Michx. (Su)

Thymeleaceae
Dirca palustris L. Leatherwood (S)

Cornaceae
Cornus alternifolia L.f. Pogoda dogwood (S or T)
C. amomum Mill. Silky dogwood (S)
C. asperifolia Michx. Roughleaf dogwood (S)
C. florida L. Flowering dogwood (S or T)
C. obliqua Raf. Pale dogwood (S)
C. racemosa Lam. Gray dogwood (S)
C. stolonifera Michx. Red osier dogwood (S)
Nyssa sylvatica Marsh. Black gum (T)

Ebenaceae
Diospyros virginiana L. Common persimmon (T)

Oleaceae
Fraxinus americana L. White ash (T)
F. lanceolata Borkh. Green ash (T)
F. pennsylvanica Marsh. Red Ash (T)
F. quadrangulata Michx. Blue ash (T)

Bignoniaceae
Campsis radicans (L.) Seemann Trumpet creeper (V)

Rubiaceae
Cephalanthus occidentalis L. Common buttonbush (S or T)

Caprifoliaeceae
Lonicera sempervirens L. Trumpet honeysuckle (V)
L. prolifera (Kirchner) Rehder Grape honeysuckle (V)
Sambucus canadensis L. Elderberry (S)
Symphoricarpos orbiculatus Moench. Coralberry (S)
Viburnum dentatum L. Arrow wood (S)
V. lentago L. Nannyberry (S or T)
V. prunifolium L. Blackhaw (S or T)
V. trilobum Marsh. Cranberry bush (S)

Liliaceae
Smilax hispida Muhl. Hispid greenbrier (V)

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A KEY TO THE ILLINOIS SPECIES OF SOLIDAGO

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The object of this study is a taxonomic analysis of the Goldenrods of Illinois. The study was made on specimens from the herbarium of the University of Illinois.

The nomenclature of the species was brought up to date and standardized according to Deam's *Flora of Indiana*, Friesner's *The Genus Solidago*, Rydberg's *Flora of the Prairies and Plains of Central North America*, and Mackenzie's treatment of Solidago in Small, *Manual of the Southeastern Flora*.

I should like to express my appreciation to Dr. G. N. Jones for his guidance and encouragement.

I have followed the plan of separating this group of plants into three generic units each possessing distinguishing morphological characteristics as follows:

I. Heads sessile; leaves punctate.....Euthamia
I. Heads distinctly pedicellate; leaves not punctate.
  A. Heads in a dense compound corymbiform cyme; bracts obtuse, longitudinally striate; achenes glabrous.....Oligoneuron
  A. Heads in a panicle or axillary racemes; bracts acute or obtuse, not striate; achenes glabrous or pubescent.....Solidago

Solidago L. Goldenrod

I. Stem glabrous up to the inflorescence.
  A. Inflorescence completely glabrous.
    a. Leaves elliptical-lanceolate with one principal vein.....S. juncea Ait.
    a. Leaves linear-lanceolate, distinctly triple-veined.....S. glaberrima Martens
  A. Inflorescence more or less pubescent or puberulent.
    a. Heads in axillary racemes.
      b. Stem angular; ultimate branches of inflorescence pubescent; leaves oval with sharply serrate margins.....S. latifolia L.
      b. Stem terete; pedicels pubescent; leaves lanceolate with unevenly dentate and hispidulous margins.....S. caesia L.
    a. Heads in a terminal panicle or raceme.
      b. Stem strongly angled.....S. patula Muhl.
      b. Stem terete or nearly so.
        c. Leaves with one principal vein; bracts obtuse or acute; achenes pubescent or glabrous.
          d. Leaves glabrous except the margins; achenes glabrous; bracts obtuse.
            e. Heads secund.....S. uniligulata T. & G.
            e. Heads not secund.
              f. Lower leaves oval or ovate-lanceolate, serrate; plants of rich woods.....S. speciosa Nutt.
              f. Lower leaves lanceolate.
                g. Lower leaves sometimes crenate otherwise entire; plants of dry woods and prairie.....S. rigiduscula T. & G.
                g. Lower leaves serrate or serrulate, oblong-lanceolate; plants of swamp or bogs.....S. uliginosa Nutt.
          d. Leaves ciliate on margins, and veins beneath; achenes pubescent; bracts acute.....S. ulmifolia Muhl.
        c. Leaves triple-veined, i.e., one pair of lateral veins more prominent than the others; heads secund.
          d. Leaves more or less puberulent or pubescent at least along the veins beneath.
            e. Involucre 2-2.8 (–3) mm. high.....S. canadensis L.
            e. Involucre 3-4.3 mm. high.....S. gigantea Ait.
          d. Leaves completely glabrous, except the scabrous margins.....S. gigantea var. leiophylla Fern.
I. Stem pubescent or puberulent throughout (rarely glabrous below).
  A. Heads not secund; rays white or yellow.
    a. Rays white; involucre 3-5 mm. high; achenes glabrous.....S. bicolor L.
    a. Rays yellow; involucre 4.5-5.5 mm. high; achenes glabrous or slightly pubescent.....S. hispida Muhl.
  A. Heads secund; rays always yellow.
    a. Leaves with one principal vein.
      b. Blades elliptical; bracts acute.....S. rugosa Mill.
      b. Blades oblanceolate; bracts obtuse.
        c. Plants with a green appearance.....S. radula Nutt.
        c. Plants with a whitish or grayish appearance.....S. nemoralis Ait.

a. Leaves triple-veined.
b. Blades oblanceolate; bracts obtuse.....S. radula Nutt.
b. Blades lanceolate or elliptical; bracts obtuse or acute.
c. Leaves lanceolate; bracts acute.
d. Involucre 2-2.8 (–3) mm. high.....S. canadensis L.
d. Involucre 3-5 mm. high.....S. altissima L.
c. Leaves elliptical; bracts obtuse.....S. Drummondii T. & G.

EUTHAMIA NUTT. BUSHY GOLDENROD

I. Stem glabrous; leaves glabrous; heads in clusters of 3-7.....E. media (Greene) Bush
I. Stem hirtellous (especially on the branches of the corymb and on the striations of the stem); leaves puberulent on the veins and margins; heads in clusters of 6-8.....E. hirtella (Greene) Bush

OLIGONEURON SMALL. ROUGH GOLDENROD

I. Stem leaves conduplicate, entire.....O. Riddellii (Frank) Rydb
I. Leaves not conduplicate.
A. Leaf margin crenate; stem pubescent.....O. rigidum (L.) Small
A. Leaf margin entire or sparingly serrulate; stem glabrous (S. ohioensis Riddell, Syn. Fl. West. States 57. 1835).....**O. ohioensis** (Riddell) G. N. Jones, comb. nov.

A TAXONOMIC STUDY OF THE ILLINOIS SPECIES OF RUMEX

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Introduction.—The most recent monograph of the North American species of Rumex was written by Rechinger[1] in 1937 in which he treated forty-seven North American species. Other authors, including Trelease,[2] and St. John,[3] have also published articles on this genus. Rechinger has done much to elucidate the species concept of Rumex by adding to the number of known species. For example, *R. salicifolius* Weinm. has been divided into several distinct species, namely *R. crassus* Rech. f., *R. californicus* Rech. f., *R. utahensis* Rech. f. *R. salicifolius* Weinm. and with other related species, has been compounded into the subsection Salicifolii.

Another important item of his clarification concerns *R. persicarioides* L. Most authors have designated the range of this species as extending from Quebec to North Carolina, Ontario to Illinois, and westward. This distribution, however, should be referred to a closely related species, namely *R. fueginus* Philippi. Philippi described this plant in 1894 as being a species distinct from *R. persicarioides* L. Subsequently St. John in 1915 thought *R. fueginus* to be a variety of *R. maritimus* and described it as *R. maritimus* var. *fueginus*. After extended study, Rechinger in writing his monograph on Rumex, discovered that *R. maritimus* occurs only in Europe and Asia and should not be included as a North American species; therefore, he treated the plant as *R. fueginus* Philippi. *R. persicarioides* L. has a limited distribution which includes eastern Canada and Massachusetts. It differs from *R. fueginus* mainly in that the tubercles are spherical and not narrowed into the midrib of the valves. *R. fueginus* is widely distributed throughout North America except for the southeastern part of the United States.

During the present study I have found ten species of Rumex occurring in Illinois. Five (*R. altissimus* Wood, *R. crispus* L., *R. obtusifolius* L., *R. acetosella* L. and *R. verticillatus* L.) are more or less ubiquitous throughout the state. *R. britannica* L., *R. fueginus* Philippi, and *R. hostatulus* Baldw. apud Elliott are uncommon in Illinois. *R. triangulivalvis* (Danser) Rech. f. which closely resembles *R. altissimus* and differs from it chiefly in the smaller size of the valves and in the narrower leaves is reported from Illinois for the first time. I have only seen one Illinois specimen.

I have recorded three imperfect specimens of *R. patientia* L., two of which have only the valve and stem characters, and the other in which there are only

[1] Field Mus. Nat. Hist. Publ. Bot. Ser. 17: 1-151. 1937.
[2] Revision of American species of Rumex occurring north of Mexico, Missouri Botanical Garden. Third Ann. Report. St. Louis 1893.
[3] *R. persicarioides* and its allies, Rhodora 17: 73. 1915.

leaves and flowers present. However, they are authentic specimens. According to its recorded geographic distribution *R. patientia* is slightly out of range because it occurs in its northern boundries in upper Michigan, extending to Missouri and westward.

R. mexicanus Meisn., as well as *R. salicifolius* Weinm., have been erroneously recorded for Illinois; however, the former inhabits Mexico and New Mexico and the latter California and Mexico. Both species have been confounded with *R. altissimus* which differs from *R. salicifolius* in the larger size of the valves, wider leaves and smaller tubercles in proportion to the size of the valves. It differs from *R. mexicanus* in the same respects except the last named distinction.

Many authors, including Gray and Small, have indicated that *R. altissimus* has one tubercle, or some of the valves have an abortive tubercle in addition (Deam). In the numerous specimens examined, I have observed at least twelve in which there are three more or less unequally sized tubercles and a few plants in which the valves contain three equally sized tubercles.

There has been one hybrid recorded for Illinois, namely *R. crispus* × *obtusifolius*, which is found only infrequently.

I am indebted to Dr. G. N. Jones for aid and advice in writing this paper. I should also like to express my appreciation to Dr. P. C. Standley, Curator of the Herbarium of the Field Museum, for the privilege of studying the specimens of Rumex that are in that institution.

Key to Illinois Species of Rumex

1. Leaves hastately lobed, sometimes linear or lanceolate; plant with acid juice; flowers dioecious or polygamous; rhizome horizontal; valves without tubercles, roseate. (Sorrel)
   2. Valves 1 mm. wide, not larger than the nutlets, and without distinct venation ..... 1. *R. acetosella*
   2. Valves 3-4 mm. wide, distinctly larger than the nutlets and with distinct venation ..... 2. *R. hastatulus*
1. Leaves never hastately lobed, not markedly acid; flowers and rogynous; roots stout; valves usually with 1-3 tubercles. (Dock)
   2. Valves entire, erose or merely denticulate.
      3. Tubercles 1-3, when 3 mostly unequal in size or seldom with all tubercles equal; pedicels with a distinct tumid joint; leaves flat, not crisped, lanceolate to ovate-lanceolate, tapering toward the base, pale green ..... 3. *R. altissimus*
      3. Tubercles usually 3, occasionally only 1, or rarely absent.
         4. Pedicels curved or flexuous, usually not more than twice the length of the valves; leaves dark green.
            5. Pedicels with a tumid joint, tubercles less than 1½ times as long as broad; lateral veins of the leaf-blades forming acute angles with the midvein.
               6. Valves 3-4 mm. long; leaves flat, linear to lanceolate, tapering toward the base ..... 4. *R. triangulivalvis*
               6. Valves usually much larger; leaves more or less crisped.
                  7. Leaves rather narrow, strongly crisped, gradually narrowed towards the base; valves 4-5 mm. long, tubercle usually 3 ..... 5. *R. crispus*
                  7. Leaves broader, often broadest below the middle, suddenly narrowed towards the base, truncate or cordate, less crisped; valves larger, tubercles absent or 1, smaller in proportion to the size of the valves... 6. *R. patientia*
            5. Pedicels without a joint or only obscurely jointed; tubercles longer than broad, lateral veins of the leaf blades forming almost a right angle with the mid-vein ..... 7. *R. britannica*
         4. Pedicels deflexed, not flexuius, 2-3 times the length of the valves; leaves flat, pale green ..... 8. *R. verticillatus*
   2. Valves with spinulose teeth.
      3. Lower leaves broad, cordate at base, the upper narrower, lanceolate; valves 5-6 mm. long, usually only 1 tubercle bearing; pedicels slender, 2½ times the length of the valves; perennial ..... 9. *R. obtusifolius*
      3. All leaves linear-lanceolate, more or less truncate at the base; valves usually 2 mm. long, slightly broader than the tubercles, the teeth long fine and bristle-like, all bearing tubercles; pedicels seldom more than twice the length of the valve; annual ..... 10. *R. fueginus*

List of Species

1. *R. acetosella* L. (Sheep sorrel) Fig. 1. Fields and waste grounds; nat. from Eur. and Eurasia; May-July; Roadside, Glenwood (O. E. Lansing, Jr. 1405). Sandy roadside, Waukegan (F. C. Gates 3063). I. C. Track, Havana (F. C. Gates 3606). Meadow, U. of I., Urbana (30849). Sand ridge, S. of oakwoods, Chicago (Agnes Chase 1350). Champaign Co. (17739). Sand, Hyde Pk., Chicago (Agnes Chase 1366). Sandy prairie, Ravenswood, Chicago (Agnes Chase). In sand, Chicago (A. Chase 1350, 1366).

2. *R. hastatulus* Baldw. apud Elliott. Fig. 2. Sandy soil; May-July. (R. hastulatus Baldw. apud Elliott), (R. englemannii Meisn.), (R. orbiculatus A. Gray), (R. hastatulus Muhl.). Sandy barrens, East Alton, Madison Co. (F. E. McDonald FM). Dry hill by French Village (H. Eggert FM). Dry sandy soil, East Alton Madison Co. (F. E. McDonald FM). 17th and Jackson aves., North Chicago (O. C. Durham FM). Sandy barrens, near East Alton (F. E. McDonald).

3. *R. altissimus* Wood (Pale dock; Peach leaved dock). Fig. 3. Alluvial soil; June. (R. britannica L.). Barnyard near Wady Petra (Virginius H. Chase 1530). Vermillion Co. (Seymour and Butts 1438). Olney (Robert Ridgeway 1003). Along I and M canal near Western Ave. (W. S. Moffatt 384). Wet meadows, Rose Hill (L. N. Johnson 14188). Olney (Robt. Ridgway 1004). Margin of Desplaines River, Riverside (O. E. Lansing, Jr. 1414). Bank of Desplaines River (Moffatt 1706). Greathouse Creephi Bridge, Mount Carmel (J. Schneck). Alluvial soil, banks of Thorn Creek, Thornton (O. E. Lansing, Jr. 1357).

4. *R. triangulivalvis* (Danser) Rech. f. Sandy soil; June. (R. triangulivalvis Rech. f.), (R. salicifolius Weinm. subsp. triangulivalvis Danser), (R. mexicanus sensu Fernald, non Meisn.). Common along Great Western Railway, Forest Park (Frank R. Filck 13 FM).

5. *R. crispus* L. (Curley dock or yellow dock) Fig. 4. Fields and waste grounds; nat. from Eur.; May-June. (R. elongatus Guss. in part). Waste grounds, Peoria (E. F. McDonald). Streets, Wheaton (W. S. Moffatt). Waste ground near Wady Petra (Virginous H. Chase). Streets and waste grounds, DuPage Co. (W. S. Moffatt 644). In Carex assoc. at foot of bluff, Waukegan (Frank C. Gates 3095). Lake Matanzas, Mason Co. (F. C. Gates 3722). Hocheiger's farm (J. Schneck). Wet grounds, Englewood (E. J. Hill), Athens (E. Hall FM). Bowmanville, Chicago (F. C. Gates 769).

6. *R. patientia* L. (Patience dock) Fig. 5. Rich open soil; nat. from Eurasia; May-June. Cold swamps, Spring Mills, Woodford Co. (F. E. McDonald). Dry roadside, N. W. of Wady Petra (V. H. Chase 70). Spontaneous from gardens, Augusta (S. B. Mead FM).

7. *R. britannica* L. (Great water dock) Fig. 6. Wet ground, Aug.-Sept. (R. orbicularis Gray), (R. britannicus aquaticus Pursh.), (R. acutus Hook.), (R. sanguineus Hook.), Slough, Algonquin (Wm. A. Nason). Wet ground, Hegenisch (E. J. Hill 92). Wet soil, Skokie Marsh, w. of Ravinia (Earl E. Sherff FM). Fountaindale (Herb. M. S. Bebb FM), Ringwood (Dr. Geo. Vasey FM). Peoria Co. (Dr. J. T. Stewart FM).

8. *R. verticillatus* L. (Swamp dock) Fig. 7. Wet ground; June-July. Back water swamp of Spoon River near Wady Petra (Virginius H. Chase 618). Ditch, W. of Wheaton (W. S. Moffatt 643). Shallow water, W. of Lombard (Moffatt). "Greenswale," DuPage Co. (Moffatt). Bernadotte, Fulton Co. (H. S. Pepoon). Muddy bank of Desplaines River, Riverside (Moffatt). Stagnant stream, Bowmanville, Chicago (Agnes Chase). Cypress Pond, Mt. Carmel (J. Schneck).

9. *R. obtusifolius* L. (Bitter dock or bluntleaf dock) Fig. 8. Fields and roadsides; nat. from Eur.; July-Aug. (R. crispatulus Michx.), (R. sanguineus L.), Waste places, Peoria (E. W. McDonald). Wet ground, Anna (A. B. Seymour 3136½), Chicago (17748). In road in front of my home (J. Schneck). My barn yard, Mt. Carmel (J. Schneck); Shady waste places, near Waldron (E. J. Hill 186). Waste places, Peoria (F. E. McDonald). Carbondale (A. B. Seymour 31361). Moist soil, Union Co. (Geo. D. Fuller and Ralph Fisher 180 FM). Jackson Co. (G. H. French FM).

10. *R. fueginus* Philippi Fig. 9. Swamps, humid sand and shady places. (R. maritimus Meisn. apud), (R. maritimus L. var. fueginus Dusen.), (R. persicarioides Pursh. in part), Woodstock (Geo. Vasey). Woodstock (Frederick Brendel). Mascoutah (W. Welsch). Ringwood (Dr. Vasey FM). Cahokia (H. Eggert FM).

THE NITROGEN CONTENT OF OAT CHLOROPLASTS

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I. *Background of the work.* Many techniques have been utilized to separate chloroplast material from the remainder of the plant cell. Chibnall (1) found that the protoplasmic suspension obtained by grinding spinach leaves in water could be fractionated by filtration through paper pulp. Nuclear and chloroplastic materials were retained on the filter, the cytoplasmic material passing through. Since nuclear material in leaves is very small in amount, the retained material was considered as essentially "chloroplastic material." Channon and Chibnall (2) ground cabbage leaves in water and warmed the suspension to flocculate the dispersed protoplasm. The ether extract of the precipitate was considered to be mainly of chloroplast origin, since cytoplasm contains little ether-soluble material. Menke (3) found that suspensions of spinach leaves ground in water would deposit chloroplastic material upon addition of ammonium sulfate.

All of these techniques may be criticized on the ground that they do not yield intact chloroplasts; hence some of the chloroplast material may remain unextracted and some cytoplasm may be carried along as an impurity in the extract. These objections are, to a large extent, removed by the technique of Granick (4). This experimenter ground turgid leaves of tobacco and tomato in 0.5 molar glucose and succeeded in obtaining intact chloroplasts in suspension, along with the remainder of the protoplasmic material. Short, slow centrifugation removed most of the non-green protoplasm, whereas longer, more rapid centrifugation deposited the chloroplasts. The plastids could then be washed by resuspending in water and flocculated by recentrifugation. Microscopic examination of the centrifugate revealed intact plastids almost entirely devoid of cytoplasmic granules. Furthermore, by colorimetric comparison of acetone extracts of leaf and chloroplasts, he was able to determine what per cent of total leaf chloroplasts he had in his suspension. This made possible the determination of total chloroplast nitrogen per leaf.

II. *Object of this work.* This work was undertaken: 1) To discover whether the technique of Granick is applicable to the leaves of cereal grasses, which contain much fibrous material. 2) To obtain information on the relative importance of chloroplasts and cytoplasm as synthesizers of protein in leaves of cereals. 3) To trace the course of protein synthesis in the chloroplasts and cytoplasm of a single leaf.

III. *The nitrogen content of green and chlorotic leaves and chloroplasts at various ages.* Kherson oats were sown in composted Flanagan silt loam in the greenhouse, and were allowed to grow until the fifth leaf was 1-3 cm. long. Leaves of the same size and physiological condition were then harvested in groups of 40. Ten of the leaves were dried for two hours in a forced-draught oven at 80° C., were then weighed to get the average dry weight per leaf, and finally were ground to a fine powder in a Wiley mill. This powder was analyzed to get the nitrogen content per leaf. The remaining thirty leaves were treated to extract the chloroplasts, according to the procedure of Granick (4). The extracted chloroplasts were analyzed for nitrogen simultaneously with the dried leaf material.

Nitrogen was determined by the microkjeldahl method of Pregl (6), all analyses, as well as blanks, being run in duplicate. The extracted chloroplasts, usually as a 2 cc. suspension, were pipetted into the digestion flasks. 20-30 mg. samples of the dried leaves were placed in other flasks. To the samples were added 2 cc. of $CuSO_4$-H_2SO_4 digestion mixture and a pinch of K_2SO_4. The mixture was then digested 15-30 minutes until clear. The digested mixture was then transferred into the still, made alkaline with excess NaOH, and steam-distilled into a flask containing 20 cc. of boric acid (1 lb. per 10 L.). The ammonia was titrated with .01 N HCl using

TABLE 1.—THE NITROGEN CONTENT OF OAT CHLOROPLASTS

Average length per leaf	Average dry wt. per leaf	Physiological Condition	Chloroplast N per leaf	Total N per leaf	N as % of dry wt. per leaf	% of total leaf N in the chloroplasts
7.2 cm	4.6 mg	Green	.084 mg	.285 mg	6.20%	30.1%
9.3	5.5	"	.119	.287	5.26	41.3
14.6	8.4	"	.137	.470	5.60	29.2
11.7	10.0	Chlorotic	.078	.261	2.61	30.0
17.6	17.7	"	.168	.495	2.79	34.2

bromcresol green as an indicator. Results were expressed as milligrams of nitrogen per leaf. The data are presented in Table I, all values being the means of two closely checking sets of results.

It can be seen that in both green and chlorotic leaves, at all stages of growth studied, the chloroplasts contain about 30-40% of the total leaf nitrogen. This checks well with the results of Granick (5), who considers further that about 80% of both leaf and chloroplast nitrogen is protein nitrogen. This would indicate that the chloroplasts synthesize large amounts of leaf protein.

IV. *The course of protein synthesis in a single leaf.* It was decided to use the first leaf of oat for this experiment, since this would avoid complications due to the translocation of soluble nitrogenous materials from other leaves. Oat plants grown in 2-gallon porcelain crocks were thinned until twelve uniform plants were left in each crock. The first leaf was harvested periodically at various stages of development, and analyzed for total and chloroplast nitrogen. The difference between these two values was called "cytoplasmic nitrogen." The last group of leaves was harvested when the ligule was visible and the leaves had apparently attained their maximum length. The results of the analyses are presented graphically in Figure 1. Again, it is found that the chloroplast nitrogen is about 30% of the total leaf nitrogen at all stages of development studied.

V. *Summary and conclusions.* A. The technique of Granick for extracting intact chloroplasts from leaves is applicable to oat leaves. B. The chloroplasts contain about 30-40% of the total leaf nitrogen in both green and chlorotic leaves at all ages studied. C. In any one leaf, chloroplasts produce about 30% of the total protein, the "cytoplasm" producing the remainder.

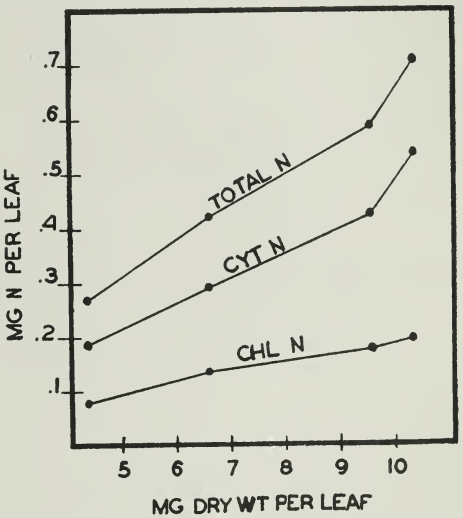

Fig. 1.—The nitrogen content of oat chloroplasts and entire leaf at various stages of development.

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NEW INTERPRETATIONS OF *SPHENOPHYLLOSTACHYS* BASED ON A PETRIFIED SPECIMEN FROM AN IOWA COAL BALL

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A specimen of *Sphenophyllostachys* with structure preserved was collected by the writers in coal ball material from the Angus Coal Mine, Des Moines Series, in Iowa. This is, we believe, the first record of an American *Sphenophyllostachys* showing structure.

The specimen consists of a portion of an isolated strobilus. Neither the base nor apex of the strobilus was preserved, so the total length of the fructification is uncertain. None of the vascular elements of the stele remain, and the tips of the bracts are but indifferently preserved. The excellent preservation of the remaining portion of the strobilus makes possible adequate and significant comparisons with previously known specimens.

The strobilus has a maximum diameter of not less than one and one-half centimeters, the axis occupying approximately four millimeters. Attached to this axis are whorls of bracts, the upturned tips of which form the free surface of the strobilus. The bracts of each whorl are inserted upon the axis at a slight upward angle and are adnate for a considerable distance from the axis, forming a cup. The free tips turn sharply upward. Each whorl, composed of approximately eighteen bracts, appears to be directly superimposed upon the bracts of the whorl below, rather than alternating with them.

On the adaxial surface of each bract are borne three sporangia, each attached to the surface by an unbranched sporangiophore. The sporangia are arranged linearly. Thus in longitudinal section of the strobilus, three sporangia are seen on the adaxial surface of each bract. The sporangiophores become free from the bract near the axis but at slightly variable points. The sporangiophores are slender, essentially cylindrical stalks, increasing slightly in size as they approach their respective sporangia, becoming greatly thickened near and at the points of attachment to the sporangia, where the sporangiophore bends slightly toward the strobilus axis, and bears a single, pendulous sporangium.

The sporangium is essentially spherical. Its wall is composed of an outer layer of radially elongated cells and two or three inner rows of much smaller cells with thin walls. Spores completely fill the sporangial cavity. They average approximately ninety microns in diameter. The spore wall has a characteristic sculpturing of anastomosing ridges with a rather definite bipolar orientation. Thus in cross-section the spore appears to be spinose. The strobilus is homosporous.

A single vascular bundle traverses the known length of the bract. Its connection with the vascular tissues of the axis cannot be determined because of incomplete preservation. Similarly, a single vascular bundle extends the length of the sporangiophore, ending at the point of attachment of the sporangiophore to the sporangium. The bifurcation of a single vascular bundle into the bundle of the bract and that of the sporangiophore takes place in the outer cortex of the axis slightly below the insertion of the bract. No further bifurcations of either of these bundles occur.

This strobilus is to be compared with those described as *Sphenophyllostachys Dawsoni*, of which the forms *alpha*, *beta*, and *gamma* have been designated. The Iowa specimen agrees in general with *S. Dawsoni* with the important exception of the difference in the number and organization of sporangiophores and sporangia. *S. Dawsoni* formae *alpha* and *beta* have been interpreted variously by Scott and Hirmer, the former ascribing to each bract two (occasionally fewer) sporangiophores, each of which becomes free near the axis and bears a single sporangium; the latter considers that a

single bundle branches in such a manner as to produce two short and one long sporangiophores alternating with two long and one short sporangiophores on adjacent bracts. Each sporangiophore bears a single sporangium. In either instance, a longitudinal section would give the picture of *two* sporangia on the adaxial surface of each bract. In *S. Dawsoni* forma *gamma*, Hirmer describes an elaboration of this branching system to produce *six* sporangiophores and sporangia for each bract, and these arranged in four cycles (a longitudinal section shows four adaxial sporangia per bract).

The Iowa specimen shows none of these conditions. There is no branching of the sporangiophore after it emerges from the surface of the bract near the axis. Three unbranched sporangiophores arise at slightly different points near the axis, are of different lengths, and each bears a single sporangium placed linearly on the adaxial surface of the bract. A longitudinal section of the strobilus thus shows the correct number of sporangia per bract, namely, three.

It would seem that for a complete understanding of this form genus a revaluation of the known specimens is necessary. The evidence points toward a separation of the genus *Sphenophyllostachys Dawsoni* formae *alpha*, *beta* and *gamma* into distinct species. The necessity of this is emphasized especially when the correlation of the fructifications with the vegetative plants which bore them is also considered. Consequently, the writers believe that the Iowa specimen itself is best considered as a species heretofore undescribed.

A MICROANALYSIS OF THE EPIDERMAL CELL WALLS BENEATH THE MIDRIB OF THE HOLLY LEAF

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In stained sections of *Ilex opaca* leaves that had gone through the paraffin process two interesting features were observed. There were thick-walled guard cells that appeared to be "petrified" by lignification and dependent in functioning upon adjacent non-lignified epidermal cells, and there were lower epidermal cells on the midrib exhibiting a distinct absence of lignin in the outer tangential walls. A microanalytical study of these latter cell walls with differentiated lignification was made.

Sections of living, mature holly leaves collected in late January were cut through the midrib with a sliding microtome to thicknesses of 12 to 15 microns. Three types of tests were applied to these sections in determining cell wall constituents and their location. Different staining reactions were checked by differential solubility reactions and by the use of the polarized microscope. The deposition and the location of four wall constituents, cellulose, lignin, pectin, and cutin, were thus determined.

Chlorozinc iodide and the hydrocellulose reaction were employed for cellulose staining tests. Cuprammonia was used to dissolve cellulose, and since cellulose is an anisotropic substance the use of polarized light and interference colors served in checking the other tests. Both staining and solubility tests brought negative results until lignin was removed from the walls, after which, these tests gave distinctly positive reactions. The resultant swelling of the walls in staining tests made the pitting less evident. Cuprammonia dissolved the non-cutinized portions of the delignified walls. Sections left in cuprammonia to remove cellulose were of little value, there being no positive test possible in the first place. As a result of cutin saponification there were disclosed lamellated structures located in the inner cutin layer over each cell. These gave the positive blue and violet colors for the cellulose staining tests. They dissolved when cuprammonia was added to a slide and gave further evidence of their plated organization in breaking down. They were doubly refractive between crossed Nicols, but only to the extent where it was barely noticeable, whereas anisotropy of the rather thick secondary walls was actually strong. It seemed that the outer tangential

secondary wall was not quite as bright as the other secondary walls.

Two lignin staining tests were applied, the phloroglucin and the Mäule reaction, revealing a high concentration of lignin in all walls except the outer tangential, the cutinized wall. This wall seemed to be more pitted than the other walls, the irregular pits extending out to the cutin layer. Sections were delignified by soaking in Chlorox for three hours. Staining tests were then repeated to make certain all lignin had been removed, and negative reactions substantiated this treatment. Lignin staining tests applied to sections treated with cuprammonia showed no apparent differences, unless a more sharply defined reaction. Sections stained by chlorozinc iodide were observed to have a brownish color which is often indicative of cellulose "masked" by lignin. Optical properties were of little help here as lignin is amorphous and isotropic. Even in its intimate association with the cellulose micelles, it will not affect their anisotropy.

Ruthenium red and methylene blue were used as pectin stains, the former known to be the more specific. Reactions revealed a high concentration of pectin in the immediate cutinized zone outside the secondary walls, as well as in the middle lamellae. In removing these compounds the sections were treated in hot 5% KOH and again washed. Staining was repeated for checks with negative reactions in these pectin regions. Delignified sections were tested with the same results. Pectic compounds are known to be colloidal and isotropic. They appeared dark between crossed Nicols where there was no cellulose present.

To obtain an accurate determination of complete cutinization sections were left in Sudan III for an hour, which brought out the boundaries of the cutin more distinctly. Sections treated with chlorozinc iodide were examined to note the effect on the cutin layer and clues as to heterogeneity of structure were evident. Slow saponification was accomplished by heating sections on slides under cover glasses and slowly adding 10% KOH. The slide was examined progressively under the microscope as the saponification increased. A thin outer strip of the cutin layer was the only part of this layer to disappear, the inner portion which was already found to contain cellulose lamellae and pectin remaining intact. Since cutin is insoluble in cuprammonia, 72% sulfuric acid, and hot dilute acids and alkalies, those sections having gone through such reagents for other tests were rechecked and found to have the cutin still in place. The outer stratum of "pure" cutin was optically isotropic in all paraffin sections, but showed up anisotropically in some fresh sections. Weak double refraction in the inner stratum coincided with the pectin zone containing the cellulose lamellae. Although cutin can be optically isotropic or anistropic when free from cellulose, its anisotropy can be considered, and was here, as indicative of cellulose deposition.

It became evident, then, that these particular epidermal cell walls are of a complex nature in the orientation of wall constituents. Different degrees of lignification in xerophytic leaf structure are not uncommon but, to the knowledge of the writer, pits extending into the cutin layer are most unusual.

A CHECKLIST OF THE VASCULAR PLANTS OF THE UNIVERSITY OF ILLINOIS WOODLANDS

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The University of Illinois woodlands, situated a few miles northeast of Urbana, Champaign County, Illinois, consist of approximately 100 acres of natural woods, fenced and maintained by the University of Illinois as a permanent preserve of wild life for scientific purposes. This property consists of two separate areas, the Brownfield Woods, and the University Woods. The following checklist is based almost entirely upon the collections of the writer during the years 1939, 1940, 1941, and 1942. The specimens are deposited in the Herbarium of the University of Illinois. Other species have been reported from time to time but since these reports are not based upon specimens they are not included in this list.

Cystopteris fragilis (L.) Bernh.
Diplazium pycnocarpon (Spreng.) Broun.
Botrychium virginianum (L.) Sw.
Bromus tectorum L.
Cinna arundinacea L.
Dactylis glomerata L.
Diarrhena americana Beauv.
Echinochloa crusgalli (L.) Beauv.
Elymus villosus Muhl.
Glyceria striata (Lam.) Hitchc.
Hystrix patula Moench.
Leersia virginica Willd.
Muhlenbergia mexicana (L.) Trin.
Panicum dichotomiflorum Michx.
Phleum pratense L.
Poa compressa L.
P. pratensis L.
P. sylvestris Gray
Sporobolus heterolepis Gray
S. vaginiflorus (Torr.) Wood
Carex albursina Sheldon
C. bromoides Schkuhr.
C. gravida Bailey
C. grayii Carey
C. grisea Wahl
C. hirtifolia Mack.
C. rosea Schkuhr.
Arisaema atrorubens (Ait.) Bl.
A. dracontium (L.) Schott
Tradescantia subaspera Ker
Juncus macer S. F. Gray
Allium canadense L.
A. tricoccum Ait.
Asparagus officinalis L.
Erythronium albidum Nutt.
Lilium michiganense Farw.
Polygonatum biflorum (Walt.) Ell.
Smilacina racemosa (L.) Desf.
S. stellata (L.) Desf.
Smilax ecirrhata (Engelm.) Wats.
S. hispida Muhl.
S. lasioneuron Hook.
Trillium gleasoni Fern.
T. recurvatum Beck.
Uvularia grandiflora J. E. Smith
Iris shrevei Small.
Aplectrum hyemale (Muhl.) Torr.
Triphora trianthophora (Sw.) Rydb.
Populus deltoides Michx.
Carpinus caroliniana Walt.
Ostrya virginiana (Mill.) K.Koch
Corylus americana Walt.
Juglans cinerea L.
J. nigra L.
Carya cordiformis (Wang.) K.Koch
C. ovata (Mill.) K.Koch
C. laciniosa (Michx. f.) Loud
Quercus bicolor Willd.
Q. imbricaria Michx.
Q. macrocarpa Michx.
Q. maxima Michx.
Q. muhlenbergii Engelm.
Celtis occidentalis L.
Ulmus americana L.
U. fulva Michx.
Maclura pomifera (Raf.) Schneid.
Morus alba L.
M. rubra L.
Humulus americanus Nutt.
Cannabis sativa L.
Urtica procera Muhl.
Laportea canadensis (L.) Gaud.
Pilea pumila (L.) Gray
Parietaria pennsylvanica Muhl.
Asarum reflexum Bickn.
Polygonum pensylvanicum L.
P. persicaria L.
P. punctatum Ell.
P. scandens L.
P. virginianum L.
Rumex acetosella L.
R. crispus L.
Amaranthus retroflexus L.
Chenopodium album L.
C. boscianum Moq.
Phytolacca americana L.
Claytonia virginica L.
Cerastium vulgatum L.
Silene antirrhina L.
S. scabrella (Nieuwl.) n. comb. (*S. stellata* var. *scabrella* Palmer & Steyermark in Ann. Missouri Bot. Gard. 25:781. 1938).
Stellaria media (L.) Cyrill.
Actaea pachypoda Ell.
Anemone canadensis L.
A. virginiana L.
Hepatica acutiloba DC.
Hydrastis canadensis L.
Isopyrum biternatum (Raf.) T. & G.
Ranunculus abortivus L.
R. septentrionalis Poir.
Thalictrum dioicum L.
T. revolutum DC.
Caulophyllum thalictroides (L.) Michx.
Podophyllum peltatum L.
Menispermum canadense L.
Asimina triloba (L.) Dunal
Lindera benzoin (L.) Bl.
Sanguinaria canadensis L.
Dicentra canadensis (Goldie) Walp.
D. cucullaria (L.) Bernh.
Capsella bursa-pastoris (L.) Medic.
Cardamine bulbosa (Schreb.) BSP.
C. douglassii (Torr.) Britt.
Dentaria laciniata Muhl.
Iodanthus pinnatifidus (Michx.) Steud.
Lepidium virginicum L.
Ribes americanum Mill.
R. missouriense Nutt.

Platanus occidentalis L.
Agrimonia pubescens Wallr.
Crataegus crusgalli L.
C. mollis (T. & G.)
Fragaria virginiana Duch.
Geum canadense Jacq.
G. vernum (Raf.) T. & G.
Malus angustifolia (Ait.) Michx.
M. ionensis (Wood) Britt.
Prunus americana Marsh.
P. serotina Ehrh.
Rosa setigera Michx.
Rubus occidentalis L.
Cercis canadensis L.
Desmodium acuminatum (Michx.) DC.
D. canescens (L.) DC.
Gleditsia triacanthos L.
Gymnocladus dioica (L.) K.Koch
Melilotus officinalis (L.) Lam.
Robinia pseudoacacia L.
Trifolium pratense L.
T. repens L.
Geranium maculatum L.
Oxalis stricta L.
O. cymosa Small
Impatiens biflora Walt.
I. pallida Nutt.
Acalypha virginica L.
Euphorbia maculata L.
Floerkia proserpinacoides Willd.
Zanthoxylum americanum Mill.
Rhus radicans L.
Celastrus scandens L.
Euonymus atropurpureus Jacq.
Aesculus glabra Willd.
Staphylea trifolia L.
Acer negundo L.
A. saccharum Marsh.
A. saccharinum L.
Parthenocissus quinquefolia (L.) Planch.
Vitis vulpina L.
Tilia americana L.
Abutilon theophrasti Medic.
Viola eriocarpa Schwein.
V. papilionacea Pursh
V. sororia Willd.
Panax quinquefolium L.
Circaea latifolia Hill
Oenothera biennis L.
Chaerophyllum procumbens (L.) Crantz
Cryptotaenia canadensis (L.) DC.
Daucus carota L.
Osmorhiza claytoni (Michx.) Clarke
O. longistylis (Torr.) DC.
Pastinaca sativa L.
Sanicula canadensis L.
Zizia aurea (L.) K.Koch
Cornus racemosa Lam.
Samolus pauciflorus Raf.
Steironema ciliatum (L.) Raf.
Fraxinus americana L.
F. lanceolata Borkh.
F. quadrangulata Michx.
Asclepias syriaca L.
Phlox divaricata L.
Ellisia nyctelea L.
Hydrophyllum appendiculatum Michx.
H. canadense L.
H. virginianum L.
Lappula virginiana (L.) Greene
Mertensia virginica (L.) Link
Verbena urticaefolia L.
Agastache nepetoides (L.) Kuntze
Blephilia hirsuta (Pursh) Benth.
Glecoma hederacea L.
Leonurus cardiaca L.
Marrubium vulgare L.
Nepeta cataria L.
Prunella lanceolata Bart.
Scutellaria lateriflora L.
Stachys tenuifolia Willd.
Teucrium canadense L.
Solanum carolinense L.
S. nigrum L.
Collinsia verna Nutt.
Mimulus alatus Ait.
Scrophularia marilandica L.
Verbascum blattaria L.
V. thapsus L.
Veronica arvensis L.
V. peregrina L.
Veronicastrum virginicum (L.) Farw.
Campsis radicans (L.) Seemann
Ruellia strepens L.
Plantago lanceolata L.
P. rugelii Dcne.
Phryma leptostachya L.
Galium aparine L.
G. concinnum T. & G.
G. obtusum Bigel.
Sambucus canadensis L.
Viburnum lentago L.
V. prunifolium L.
Campanula americana L.
Lobelia inflata L.
L. siphilitica L.
Achillea millefolium L.
Actinomeris alternifolia (L.) DC.
Ambrosia elatior L.
A trifida L.
Arctium minus (Hill) Bernh.
Aster ericoides L.
A. sagittifolius Wedem.
A. Shortii Lindl.
Bidens vulgata Greene
Cacalia muhlenbergii (Sch.-Bip.) Fern.
Cirsium vulgare (Savi) Airy-Shaw
C. arvense (L.) Scop.
Erigeron annuus (L.) Pers.
E. canadensis L.
E. philadelphicus L.
Eupatorium purpureum L.
E. rugosum Houtt.
Helianthus decapetalus L.
Lactuca scariola L.
L. floridana (L.) Gaertn.
L. spicata (Lem.) Hitchc.
Polymnia canadensis L.
Rudbeckia laciniata L.
R. triloba L.
Solidago rugosa Mill.
Taraxacum officinale Weber
Vernonia missurica Raf.

THE RATE OF TRANSPIRATION IN TWO OATS VARIETIES GROWN UNDER VARYING SOIL MOISTURE LEVELS

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Studies are being made in the laboratory of plant physiology at the University of Illinois on the metabolism of cereal grasses. Considerable emphasis has been placed on the relationship of the nitrogen metabolism to the vitamin content during the growth period. It is obvious that if the plant is to be used commercially as a protein source, it will be advantageous to get maximum protein content and dry weight yield. A continuous chronological study of the metabolic changes during the various growth stages of the plant from the vegetative to the reproductive phase through maturity is required.

There are several stages of plant development that may be distinguished by a detailed chemical analysis of the plant tissue. Burd (2) divided the growth of barley into three periods: a preliminary period of eight to nine weeks from planting characterized by intense vegetative activity; a second period of about six weeks during which structural differentiation takes place and flowering occurs; a third period of about three weeks characterized by a loss in weight and by dessication of all parts of the plant. As an indication of these various stages of growth Burd noted that at the beginning of the second period there was a sharp decline in the moisture content of the leaves. At the beginning of the third period there was another decline in the moisture content of the leaves.

Loehwing (3) and his associates studied mineral nutrition in relation to reproduction in higher plants. The results showed that important metabolic, as well as structural, changes originated in the period between the origin of floral primordia and full bloom. With pot culture studies under conditions of adequate mineral nutrition there occurred a sudden and thereafter continuous increase in the rate of transpiration at about the time of flower inception. Tissue analyses showed that the plants actually underwent a change in water balance toward the direction of lower water content. Frequently the increase in transpiration and change in water balance could be noted before the appearance of any visible floral structures. The experiment reported here was set up to study the varietal differences of oats in respect to the relation between changes in their water balance and morphological differentiation.

Two varieties of spring oats, Kherson and Illinois 30-2088, were seeded in glazed porcelain pots each containing 8 kilograms of composted Flanagan silt loam. The coleoptiles appeared three days after seeding. The plants were uniformly watered until the first leaf was 5 cm. high. Water was then added or withheld from the soil so that 10 pots, each containing 10 plants, were maintained at soil moisture levels of 15%, 22.5%, 30%, 37.5% and 45%. The water holding capacity of the soil was 66%. The pots were weighed three times a week and the desired moisture level maintained by adding water. Part of the water was added to the surface and part to the lower levels by means of inserted glass tubes.

Twenty-eight days after seeding a sudden increase in transpiration was noted in both varieties grown at all soil moisture levels (Fig. 1). An examination of the stem and growing point showed that the stem was starting to elongate and the growing point was beginning to differentiate. Bonnett (1) found that the oat stem passed through two stages of development. In the first stage the growing point remained short, the leaf initials differentiated, the leaves grew, and tiller buds developed in the axils of the leaves at the base of the stem. In the second stage the internodes of the stem elongated, and the branches, spikelets, and flower parts differentiated

and developed. The results of this experiment would indicate that the sudden increase in rate of transpiration took place at the beginning of the second stage.

In both varieties grown at all soil moisture levels, the peak of transpiration was reached on the same day. After an initial fall the rate of transpiration again rose. It was at this period that the two varieties differed. The Illinois 30-2088 rapidly regained a high rate of transpiration which was maintained for the duration of the experiment while the Kherson continued transpiration at a reduced level. The total amount of water lost by transpiration was greater at each soil moisture level in the Illinois 30-2088 variety than in the Kherson variety.

If we assume that the higher level of transpiration is related to the morphological differentiation accompanying the reproductive phase, then the Illinois 30-2088 was developing through the reproductive at a more rapid rate than Kherson. This interpretation is further borne out by the fact that the inflorescences of the Illinois 30-2088 immerged 4-5 days before those of the Kherson.

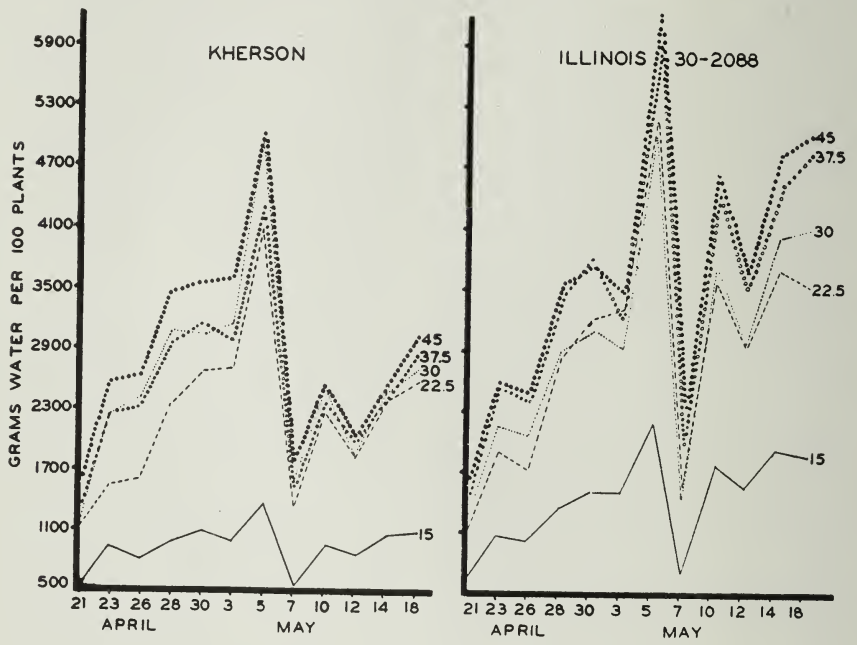

Fig. 1.

Table 1.—Total Grams of Water Lost (100 Plants)

	15%	22.5%	30%	37.5%	45%
Illinois 30-2088	17117	34504	35184	41785	43493
Kherson	11428	26182	30922	30004	33661

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SOME GROWTH RESPONSES OF *SOJA* AND *VINCA* TO VITAMINS[1]

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Recent researches on the effects of the various vitamins on the growth of higher plants indicate that the degree of stimulation varies with the species of test plant employed as well as with concentration of the reagent (1, 2, 3, 4, 5, 6, 8, 9). Scrutiny of the literature suggests that plant responses to vitamin-like stimulants may perhaps be correlated with the normal rate of over-all growth of plants. Plants known to grow rapidly under normal conditions often respond differently than those growing more slowly, especially when stature is taken as the growth criterion (4).

In order to test this hypothesis, experiments were undertaken with two species of contrasting growth habit. The Manchu variety of *Soja max* was selected for its rapid growth, especially in the early stages, and compared with the slow-growing periwinkle, *Vinca rosea*, in response to three synthetic vitamins: thiamin chloride, riboflavin, and ascorbic acid. By study of the root system as well as the shoot, an attempt was made to determine if there was a differential response to the three stimulants employed.

Methods.—One-week-old seedlings were transplanted from sand flats to washed gravel cultures in two-gallon jars. The gravel, free from organic matter and sterile at the beginning of the experiment, was supplied with Withrow's nutrient solution, feeding being uniformly maintained by gravity (fig. 1). Plants were grown during July and August under ordinary greenhouse conditions.

The two test species were arranged in five series of treatments with twenty plants in each series as follows:

Series 1: nutrient plus 5.0 p.p.m. vitamin B_1 (thiamin chloride).

Series 2: nutrient plus 2.5 p.p.m. vitamin B_2 (riboflavin).

Series 3: nutrient plus 5.0 p.p.m. vitamin C (ascorbic acid).

Series 4: nutrient plus combination of B_1, B_2, and C in the above concentrations.

Series 5: nutrient Control. Withrow's solution only.

Merck's vitamins were used in all cases.

The jars were completely drained at two-day intervals and 2 liters of fresh nutrient solution added; traces of minor nutrients (Mg, Zn, B, Cu, Fe) were added. Moisture was maintained at constant level by adding distilled water as needed between changes of the nutrient solution.

The soybeans were in bud when harvested four weeks after transplanting and were about three feet tall. *Vinca* plants were permitted to grow to flower and were harvested at seven weeks when about twelve inches tall.

Measurements of height, root and shoot fresh weight, and total leaf area were made immediately at harvesting. Subsequently, total tops and roots were dried in vacuum at 85° C. to determine respective dry weights and moisture of individual plants. Leaf areas were measured in a photo-electric areameter (7). The resulting data are given in tabular form in table I.

Discussion.—Inspection of the data for *Vinca* (table I) shows a statistically significant increase in total leaf area of the vitamin combination over the controls. No similar significant effect on leaf area is noticeable in any of the single vitamin treatments. In fact, 2.5 p.p.m. of riboflavin reduced leaf area and root dry weight but the effect is barely significant in the leaves. The difference in fresh and dry weight of roots in the riboflavin series of *Vinca* substantiates the hydration effect of this reagent previously reported by Dennison (6) for egg plant tissues. Entire plants of *Vinca* supplied with riboflavin are somewhat less luxuriant then the controls if dry weight and

[1] This research was supported in part by a grant from the American Association for the Advancement of Science.

leaf areas are taken as criteria. Other than the diminution of leaf area with riboflavin, the single vitamin treatments of *Vinca* are essentially neutral, responses which stand in contrast to the three-vitamin combination which induced increase in leaf area. Failure of slow-growing *Vinca* to respond is in contrast with the results of Bonner (4) who reported stimulation of several slow-growing species with the application of vitamin B_1; this reaction is in agreement, however, with the results obtained by several workers on a variety of genera (1, 8, 9).

The only exception to the lack of favorable response of *Vinca* to single vitamins is found in the dry weight increase of tops supplied with 5 p.p.m. of thiamin. The results in terms of fresh and dry weight indicate that these are not stimulated by either riboflavin or ascorbic acid in *Vinca*, an example of a slow-growing species.

Significantly different responses are exhibited by the soybean. Riboflavin exerts a distinctly inhibitory effect in concentrations of 2.5 p.p.m., especially upon the root system (table I). The response suggests some injury from this concentration in the soybean. The contrast between *Vinca* and *Soja* to identical concentrations of riboflavin implies a lower tolerance of *Soja* to this reagent.

Soja exhibits a significantly favorable response to thiamin chloride both on a fresh and dry weight basis and also the percentage of dry weight in the roots. Although growth of both root and top are

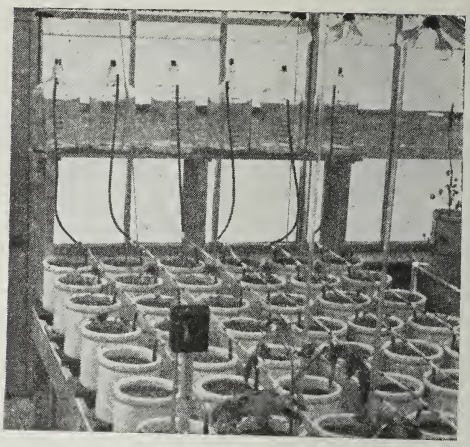

Fig. 1.—Gravity feed system used in supplying nutrients.

stimulated by 5 p.p.m. of thiamin chloride, increased growth of soybeans occurs primarily in the tops. Studies of other investigators on excised roots in tissue culture have disclosed the favorable effects of vitamin B_1 on root growth; Bonner (3) further states that B_1 is a general root-growth factor in actively growing plants. Other workers have indicated the efficiency of the treatment of cuttings. In a recent publication, however, Hitchcock and Zimmerman (10) do not recommend B_1 for either cuttings or the growth of plants in soil. The above response of *Soja*, however, suggests that its influence is by no means limited to the root system.

TABLE I.—GROWTH RESPONSES OF SOJA AND VINCA TO VITAMIN TREATMENTS[a]

	Vitamin	Fresh Weight		Dry Weight		Percentage Dry Weight		Top / Root Ratio[b]	Total Leaf Area
		Root	Top	Root	Top	Root	Top		
		gm.	*gm.*	*gm.*	*gm.*	%	%		*cm.*^{2}
VINCA	B_1	3.9	9.2	.70	.97	18.0	10.6	1.39	206
	B_2	3.2	6.9	.54	.73	16.9	10.5	1.35	180
	C	3.6	8.1	.70	.78	19.4	9.7	1.11	204
	Combination	3.4	9.1	.65	.88	19.1	9.7	1.35	235
	Control	3.4	8.6	.77	.86	22.6	10.0	1.12	196
SOJA	B_1	5.8	20.1	1.51	3.55	26.1	17.7	2.35	
	B_2	2.8	14.4	.66	2.45	23.2	17.0	4.30	
	C	3.2	16.2	.88	2.66	27.5	16.5	3.6	
	Combination	4.7	17.2	1.09	2.98	23.4	17.3	4.3	
	Control	5.0	16.9	1.10	2.88	22.2	17.0	4.5	

[a] Average of 16 plants.
[b] Based on dry weight.

Roots in the thiamin series of *Soja* were more fibrous, longer, and more highly branched than in controls. Root systems in controls and all other *Soja* series were smaller, woody, less fibrous, and generally less luxuriant. The low Top/Root Ratio in the thiamin chloride series of the soybean reflects the larger root system and improved balance between root and shoot. A similar relationship was noted by Bonner and Bonner (2) in *Cosmos*.

It is difficult to account for the elimination of the beneficial effect of thiamin in the three-vitamin combination but it may possibly be attributable to the presence of 2.5 p.p.m. riboflavin which singly in this concentration is especially repressive on root growth.

Vitamin C was not significantly beneficial in any general fashion in the growth of either *Soja* or *Vinca* with the exception of the percentage dry weight in *Soja*. Plants receiving ascorbic acid were much higher than the controls or any other series in this test. A similar stimulative effect was reported by Dennison (6) for tobacco by the use of ascorbic acid. These data suggest a variation in the metabolic index of the plants in question and any study of the connotations of this response will require further quantitative experimentation.

In both *Vinca* and *Soja* the gross superficial appearance of the growing plants was not indicative of the compositional differences shown in table I; all series were similar in their general appearance. An examination of the percentage of dry weight in the series' tests is further indicative of quantitative variations not apparent in gross dry and fresh weights. A similar observation was reported by Dennison for tobacco (6). This particular aspect of the response of plants to vitamin treatments has received little attention in the literature; only comparative fresh and dry weights are usually reported.

It is noteworthy, however, that *Soja* was consistent in its positive response to vitamin B_1 in the entire series of tests with one exception found in the percentage of dry weight in the tops.

Summary

1. In view of the responses of the two test species and their known differences in normal rate of growth, the foregoing data suggest that the slower-growing form, *Vinca*, is less responsive than *Soja* to external sources of thiamin, riboflavin, and ascorbic acid in the concentrations used and under the growing conditions employed. Normally rapid-growing forms may thus prove to be more favorable test plants in vitamin studies because of their immediate and more distinctive responses to treatment.

2. *Soja* responded to vitamin B_1 by a significant increase in dry and fresh weight of both tops and roots over the controls.

3. The relative increase in root growth in *Soja* was evident in a lower Top/Root Ratio than in either the controls or other vitamin treatments.

4. Vitamin B_2 was not significantly beneficial in its effects on the growth of either *Soja* or *Vinca*.

5. Vitamin C was not significantly beneficial in its general effects on the growth of either *Soja* or *Vinca*.

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THE WHITE-BRACTED HYMENOPAPPUS STILL GROWS IN ILLINOIS

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Just a century ago—in July, 1842—Charles A. Geyer collected the White-bracted Hymenopappus, *Hymenopappus scabiosaeus* L'Hér. (*S. carolinensis* of current botanical manuals) in sandy soil near Beardstown, Cass County, Illinois. In June, 1845, Dr. S. B. Mead collected the plant in Mason County, and eleven years later—on May 23, 1856—Elihu Hall collected it again in Cass County. These three records probably are the basis upon which the species was included in Lapham's 1857 list of Illinois plants and upon which the range given for it in Gray's *New Manual of Botany* (1908) and Britton and Brown's *Illustrated Flora* (1913) includes Illinois. During 85 years no further collections of the plant were made in the localities in which it was first discovered and no records of its occurrence in other parts of Illinois were made.

In the summer of 1941 the writer collected the White-bracted Hymenopappus in the southeastern part of Kankakee County. This latest locality, approximately 50 miles north and 130 miles east of the earlier recorded localities, lies about 145 miles from them. The site occupied by the plant is almost exactly one and one-half miles due east of the town of Wichert. It lies on the western section line of Section 25, Township 30 North, Range 12 West, about midway between the northwestern and southwestern corners of the Section.

The range of the White-bracted Hymenopappus lies generally to the south of Illinois. It is defined in Rydberg's *Flora of the Prairies and Plains of Central North America* (1932) as from "South Carolina westward to Kansas and southward to Texas and Florida," in Britton and Brown's *Illustrated Flora* as from "Illinois and Texas east to South Carolina and Florida," and in Gray's *New Manual of Botany* as Illinois to South Carolina and southwestward. In habitat, the plant is restricted to sandy barrens.

Since the publication of these manuals, little additional evidence of the northern limit of the species has been published. Charles C. Deam, in his *Flora of Indiana* (1940) records the plant in two widely separated Indiana counties, Vigo and Stark. Collections were made in Vigo County, near Terre Haute, in 1890 by Blatchley and in 1925 by A. R. Bechtel. Four sites were found in Stark County, in northwestern Indiana, by Deam in 1930.

The isolated occurrences of the plant in Illinois and Indiana, hundreds of miles north of its normal range, is not easily explained. Both the Illinois and the Indiana records are for sandy habitats close to rivers. The Illinois and Stark County, Indiana, sites form an interrupted chain along most of the length of the Illinois-Kankakee river valleys, and the Vigo County, Indiana, sites are close to the Wabash River. Such facts would suggest transportation by water fowl, except that what is known about migratory routes and food habits almost certainly precludes the possibility. However, smaller birds following overland migration routes might have served as chance carriers.

It is possible, also, that these northern occurrences of the plant represent surviving outposts of a former general range and date back, perhaps, to a warmer age or the time when the Gulf of Mexico extended northward to and beyond the present Ohio River valley. They might then be regarded as remnants of a retreating southern flora, persisting only where, in small localities, some factor of soil or climate continues to favor their existence.

A PRELIMINARY INVESTIGATION OF THE EFFECT OF THE DESCALING OF WINTER BUDS ON THEIR GROWTH IN EAST CENTRAL ILLINOIS*

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This study arose from a preliminary investigation conducted by Dr. Priestly of Leeds University, England.[1] Priestly's work consisted only of the effect of winter climate on the viability of descaled buds. Priestly's results are being checked with those of this experiment in determining whether buds live through the winter without bud scales. A study was made of buds after they had been three months in the descaled condition, to determine whether or not there were any structural modifications occurring in the exposed scales between the time the buds became dormant and the time they broke their dormancy in the spring.

Thirty-five buds from specimens of each of these trees, *Liriodendron tulipifera*, *Betula nigra*, and *Tilia europea* were descaled the fifteenth of November, 1941. The buds were all tagged with linen cloth tags which were dated and duly marked with India ink, and then coated with paraffin before being tied to the twig bearing the descaled bud. These buds were carefully watched for the duration of the winter. After three months, twigs bearing descaled buds were brought into the laboratory and sections of the bud scales of the undissected buds made. These were the control groups. Sections were made of the second pair unexposed, and second pair exposed of the dissected buds. The sections were about twenty-five microns in thickness.

In the buds of *Liriodendron tulipifera* it was observed that the exposed leaf turned brown and later dried up. There was no change in the scales except in the deposition of resin in each of the epidermal cells of the second scale which was exposed.

Tilia (Dissected buds). In the second pair of scales exposed there was found—cutin, pectin, suberin, and resinous deposits in the lower epidermis. These materials were identified by the conventional microchemical tests. There were also scattered areas of lamellated material for which we could find no positive test. This material was thought to be mucilage. (The deposits are assumed to be mucilages because of their transparency in the fresh material and solubility in water. The material was thought to have coagulated as the sections were dehydrated in the making of the slides. The unidentified material has resemblance in crystalin form to inulin crystals.

Diagrams of cross sections of the second bud scales unexposed and exposed indicate that there is a difference in the number of the unidentified deposits and likewise in their distribution. In the unexposed scales, the deposits are scattered irregularly. In the second exposed scale the deposits are in the center of the section and evenly distributed throughout the middle of the scale and there is an appreciable increase in the amount of this material. There was no increase in the thickness of the cuticle in the exposed scale.

Betula (The first and second scales were sectioned in the same manner as were those in the preceding buds). Examination of the sections showed that there were no appreciable modifications.

Summary. Priestly's results indicate that a number of buds lived through the winter in the absence of the scales and in *Aesculus hippocastanum* and *Castanea sativa* almost half of the buds lived. In this experiment seventeen of the River birch buds lived and thirteen of them died, thus giving a percentage of 56.7%. Twenty-nine out of thirty-two tulip tree buds survived for a percentage of 90.6%. It is not known just how many basswood buds would have survived, because this

* Contribution from the Collegiate Section.
[1] Priestly.

part of the experiment was maliciously destroyed by some unappreciative individual.

In this experiment more buds survived than in the experiment recorded by Priestly. Some of the buds were small and it is highly probable that in the removal of the scales they were mutilated to the extent that they did not survive. Some of the buds of river birch in this experiment were victims of faulty technique we are quite sure.

Priestly found that, when dormant, the buds contain very little water and are relatively insensitive to the external conditions, while actively growing buds absorb much water and are easily killed by frosts or sharp changes in temperature. We had no spring frosts after the buds started to swell so we cannot draw any conclusion as to the importance of the amount of water contained in the parts which grew.

Some naked buds such as those of the *way-faring tree (Viburnam lantans)* are resistant to winter conditions and the buds of *Cornus sanguinea* and *Alnus rotundifolia*, where the scales often do not completely enclose the leaves within, are also resistant to winter conditions. In this country attention is called to the pawpaw tree which has no scales, but yet is able to endure the winter climate.

This as well as the results of the two experiments hint that bud scales, as protective structures, are not so very important. The problem probably needs more experimental data before being concluded definitely.

A STUDY OF THE PHYTOPLANKTON OF CRAB ORCHARD LAKE

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Crab Orchard Lake is that body of water formed by a dam across Crab Orchard Creek at the Jackson-Williamson county line in Southern Illinois. (Fig. 1). The stream and its tributaries have a drainage basin of 200 miles. The lake at the spillway level covers about 7,000 acres. It is about four miles wide at the widest part and about 10 miles long. Its greatest depth, in the stream bed at the outlet tower, is 14 meters. The stream bed is three or four meters below the surrounding land. Thus the greatest depth out of the stream bed is 10 meters. The land which was flooded was badly eroded leaving many gullies in the bottom of the lake; consequently it was necessary to place buoys at the two stations out in the lake to mark those depths used in our experiments.

Four stations were established across the lake for a distance of one and one-fourth miles, beginning at the southern edge. See figure 1. Station CO-1 is in a cove on the south side of the lake well protected by headlands on the east and west. A small stream emptied into this cove during the wet seasons. Only surface samples were taken here, and these in the mouth of the stream where the water was not over two feet deep.

Station CO-2 was taken in the old stream bed. When water is at the spillway level this station is not over 13 meters. (The lowest the water was last summer was 10 meters deep.) Along the banks of the old stream were small trees and shrubs. These are now completely covered and are found only when they tangle the lines of the collecting tube. Small bits of wood are found in samples from this station.

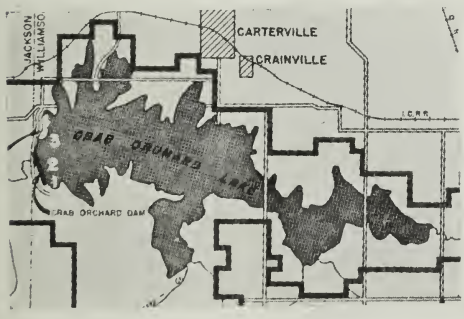

Fig. 1.—Outline Map of Crab Orchard Lake.

Station CO-3 is about three-fourths of the way from Station CO-2 to the north shore. Its greatest depth was five meters. At the low water stage it was about three meters. The soil here had been cultivated and was most recently planted in corn.

Station CO-4 is in a shallow cove on the north shore where the soil had been graded to make a smooth beach. This had grown over with weeds before the land was flooded. The water here was only about two feet deep. Surface samples were taken here.

The dam was closed May 10th, 1940, and the water went over the spillway for

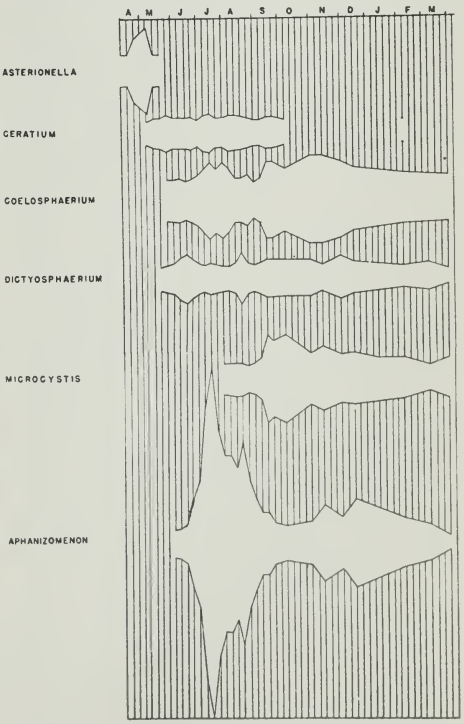

Fig. 2.—Diagram of average net algae at Station CO-2.

the first time during the night of February 1st, 1942. Most of these data were taken before the water had reached spillway level. The collections from the surface were taken in a dip pan and from water below with a collecting tube of one liter capacity. Samples were put through a collecting net of silk bolting cloth and washed into 100 c.c. of Transeau's Fluid for storage. Counts of the numbers of organisms were made in a Sedgwich-Rafter cell of 1 c.c. capacity. At Stations CO-2 and CO-3 the samples from below the surface were taken at one meter intervals.

Fig. 2 shows the average of six net algae that were abundant enough long enough to be charted. These were collected at Station CO-2. As was expected the number of individuals was small and the genera few early in the spring. The collections were made each week until the first week of October; then every two weeks until the second week of December. At this time a question of jurisdiction arose since the upper end of the lake became a defense area. Then the lake was covered with ice too thick for a row boat but not thick enough to support a collector and all the equipment. The first organisms to appear maintained little variation in a restricted range. *Asterionella* disappeared the last of May. Only one individual of this alga has been seen this spring. *Ceratium* varied the least of any while it was seen but was gone the second week in October, except those found the second week in February. The others continued in the collections from the time they were first seen until the last collection was made the first week in April. The most striking increase was made by *Aphanizomenon* when it reached 700,000,000 organisms per cubic meter the third week of July. The decrease was more rapid than the increase. At Station CO-1 *Microcystis* became so thick it could not be collected in the net, but was allowed to rise to the top of the collecting pan and 100 c.c. of this material was taken as a sample.

Vertical distribution of these organisms at Station CO-2 is shown in Fig. 3. The greatest number of organisms was found at two meters in *Asterionella* and *Coelosphaerium*, at three meters in *Dictyosphaerium* and *Aphanizomenon*, at four meters in *Ceratium*, and at the bottom in *Microcystis*. These represent the average

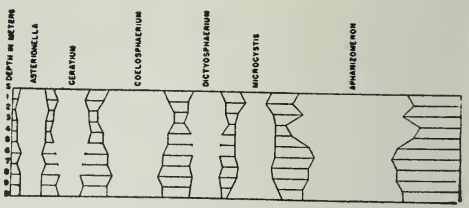

Fig. 3.—Vertical Distribution at CO-2.

numbers taken during the middle of the season for each.

Vertical distribution at the four stations is shown in Fig. 4. The letters indicate the name of the organism and the distance between the short vertical lines shows the number of individuals of each alga. This gives a rough idea of the distribution from top to bottom of the lake. *Dictyosphaerium* was not seen in the

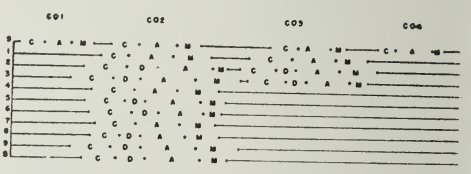

Fig. 4.—Vertical distribution of four algae at the four stations in Crab Orchard Lake. C = Coelosphaerium. D = Dictyosphaerium. A = Aphanizomenon. M = Microcystis. Sept. 12, 1941.

upper two meters at any station and was also absent from the four and seven meter samples taken at Station CO-2. Here again the greatest number occurred at the three-meter depth at CO-2 and at the two meter depth at CO-3. The surface samples were very much the same at all stations, although when the wind was from the north *Microcystis* and *Coelosphaerium* collected in large quantities on the surface at Station CO-1.

Among the other net algae found in sufficient number to be recorded were the following:

1. Anabaena
2. Ankistrodesmus
3. Arthrospira
4. Chlamydomonas
5. Chlorella
6. Closteriopsis
7. Closterium
8. Coelastrum
9. Cosmarium
10. Crucigenia
11. Cylindrospermum
12. Diatoms
13. Dinobryon
14. Eudorina
15. Euglena
16. Gloeocapsa
17. Gonium
18. Gonyaulax
19. Mougeotia
20. Netrium
21. Oedogonium
22. Oocystis
23. Oscillatoria
24. Pachycladon
25. Pediastrum
26. Pleurotaenium
27. Scenedesmus
28. Schroederia
29. Sphaerocystis
30. Spirogyra
31. Spondylosium
32. Staurastrum
33. Stigeoclonium
34. Tetraedron
35. Ulothrix
36. Zygnema

A PRELIMINARY INVESTIGATION OF THE EFFECTS OF NAPHTHALENE ACETIC ACID UPON THE GROWTH AND COMPOSITION OF OATS

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Previous experiments (1) have indicated that the substance naphthalene acetic acid may have an effect on the morphology and yield of some plants grown in pot culture when it is supplied in the nutrient medium. Other experiments have shown that this substance is active in growth correlation (2). The preliminary investigation described here is an attempt to observe in somewhat more detail the effects of naphthalene acetic acid on the growth and composition of young oat plants, (Ill. variety 30-2088).

The plants were grown in crushed quartz gravel in 6½ inch glazed pots. They were supplied nutrient by a sub-irrigation system from three gallon bottles. Each bottle supplied two pots. By means of an automatic time clock, the system was irrigated and drained eight times daily. The nutrient solution was renewed every two weeks. There were eight groups of nutrient supply: the control or plain salts medium, and seven dilutions of naphthalene acetic acid in this medium, 0.005, .01, .05, 0.1, 0.5, 1.0, and 2.0 mg. per liter. There were twelve pots with sixteen plants per pot of each dilution and the control. These plants were harvested at the end of six weeks before the development of the first node. The pots were immersed in a large tub of water and the plants were gently extricated from the gravel to preserve as much of the roots as possible. The roots and tops were separated and rapidly dried in a moving current of hot air (85° C.). They were then pulverized in a Wiley mill and the material analyzed for its total nitrogen content.

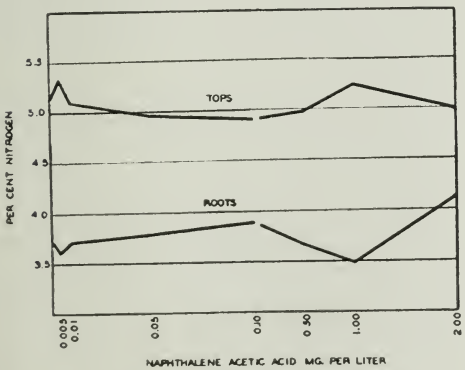

Fig. 1.—The effect of various concentrations of naphthalene acetic acid on the per cent total nitrogen in the tops and roots of young oat plants. Note the inverse relationship.

The total nitrogen was determined by the Kjeldahl-Gunning method (with $CuSO_4$ catalyst) with micro-digestion and distillation equipment. The average sample weight was 50 milligrams. Determinations were made in triplicate. Results are shown in Fig. 1. The inverse relationship of the graph suggests that some influence of naphthalene acetic acid on transport might be involved.

A difference in appearance of the plants was noted while they were growing. Those in concentrations of naphthalene acetic acid above .5 mg. per liter were much darker in color than any of the others and their leaves did not fall aside from the stems as in normal growth. The chlorophyll content of the dried tops was compared colorimetrically in acetone extracts with the results shown in Fig. 2.

Ascorbic acid determinations were made on 5 gram samples of fresh tissue at the time the plants were harvested. The amount found in all samples was unusually constant, having extreme values of 25-29 mg. per cent ascorbic acid. 2-6 dichlorophenolindophenol was used to titrate the metaphosphoric-trichloroacetic acid extract of ascorbic acid.

The dry weight yield of both tops and roots generally was lowered as the concentration of naphthalene acetic acid increased, except that a slight increase over the control occurred in the lowest concentration, 0.005 mg. per liter.

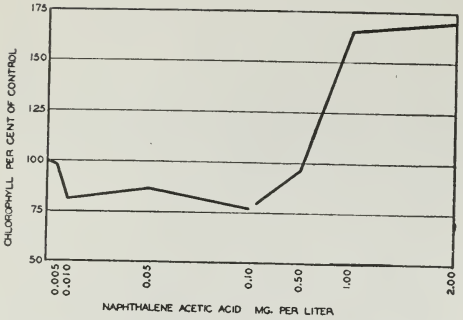

Fig. 2.—The effect of various concentrations of naphthalene acetic acid on the chlorophyll content of the tops of young oat plants.

The data obtained in this preliminary study show that naphthalene acetic acid supplied in nutrient solutions affects the total growth of oat plants and the amount of chlorophyll in the leaves. It also affects inversely the amount of nitrogen in tops and roots. It has no apparent effect on the ascorbic acid content of the tops.

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PRELIMINARY STUDIES ON RIBOFLAVIN (VITAMIN B_2) CONTENT OF PLANT MATERIALS

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It will probably be agreed that the last decade has brought forth much startling and important knowledge in regard to the chemistry and physiology of the vitamins and there is every indication that there is still much to be done. One of the most interesting and intensive phases of this work has been the isolation and identification of the vitamins of the "B-complex." Aside from the common feature of water solubility, each one seems to be universally distributed in living, growing organisms which probably indicates that most of them, at least, are indispensable to all forms of life. Several members of this group which have been most studied, thiamin, riboflavin and nicotinic acid, have been shown to exert their influence as prosthetic groups for enzymes or as co-enzymes in cellular respiration. The author of a recent review (1) has stated that over 700 papers were written on the water soluble vitamins during 1941. However, even a cursory reading of the text reveals that the proportion of papers dealing with plant-vitamin relationships (excluding determinations on foods) is exceedingly small.

Green plants are known to be the primary seat of vitamin synthesis not only for themselves (wherein they are not vitamins according to definition) but for all animals dependent upon them directly or indirectly for food. The study of vitamin relationships in plants should be a rich field of physiological endeavor but has been slow getting started mainly because of a lack of adequate methods for their determination. A recent publication by Williams and co-workers (2) presents microbiological assay methods which require little outlay for equipment and appear to be reasonably accurate.

The present investigator has applied the microbiological method for riboflavin to plant materials with a view of learning something about the occurrence, synthesis and possible functions of the substance in plants. One phase of the problem which is considered to be important is the relation of mineral nutrition to vitamin content of cereal grasses and is being studied at the present time in the laboratory at the University of Illinois.

The study of riboflavin in plants seems to have been almost untouched up to the present time but experiments with other vitamins can serve as a guide. Riboflavin content of several plant materials is presented and is used to illustrate possibilities for further research. Bonner (3) has studied the thiamin distribution and transport in tomato plants and reports that the thiamin content, on the basis of gammas per gram of dry weight, is highest in the youngest leaves and falls off with each successive leaf to a low figure in the oldest. The accompanying data on tobacco and tomato show no difference between the riboflavin content of young

TABLE I

Plant	Part	Riboflavin in gammas per gram dry tissue
Tobacco	Growing point and youngest leaves	10.88 ± 0.1
	Leaves, mature	11.15 ± 0.1
	" , senescent	8.00 ± 0.8
Tomato	Growing point and youngest leaves	23.90 ± 1.0
	Leaves, growing rapidly	23.71 ± 1.5
	" , mature	20.73 ± 1.0
	" , senescent	14.37 ± 1.0
Oat (Flowering stage)	Roots	9.73 ± 0.5
	Leaves	23.38 ± 2.0
	Stem (includes leaf sheaths)	4.35 ± 0.4
	Spikelets	14.90 ± 0.1
Coleus	Leaf margins (chlorophyl)	21.63 ± 0.9
	Leaf centers (no chlorophyl)	22.17 ± 1.3
Magnolia	Flower petals	15.76 ± 1.3
Spinach (Var: Old Dominion)	Reproductive, male	11.58 ± 0.3
	" , female	16.49 ± 1.0
	Vegetative, male	8.75 ± 1.0
	" , female	10.48 ± 1.0

and mature leaves but shows a low value for senescent leaves. This may be due to destruction or removal of riboflavin from necrotic cells. By means of girdling experiments, Bonner was able to conclude that thiamin is apparently synthesized in the mature leaves and transported up or down the stem to the growing leaves and to the roots. This technique might be profitably applied to the other B vitamins.

The data on the oat plant indicates that the leaf is the place of synthesis of riboflavin. Its occurrence in the stem might be in part due to transport to the flowers and to the roots. The difference between the concentration in tobacco and tomatoes is interesting but should be confirmed because the tobacco samples were not analysed until several months after they were dried. They were stored at room temperature in light-tight containers.

As early as 1935, Kuhn and Kaltschmitt (4) investigated the possible relationship between riboflavin and chlorophyl in the green leaf but came to no definite conclusion. The results of analysis of variegated cloeus leaves and of magnolia petals would lead one to believe that there is no necessary relationship between chlorophyl and riboflavin content. It is especially interesting if one assumes that the only difference between the cells of the margin and those of the center is presence or absence of chlorophyl.

Loehwing's (5) investigation on the chemistry of sex expression in spinach suggested that there might be a difference in vitamin content between male and female because of apparent differences in metabolic activity. The female plants, which seem to have a higher rate of nitrogen metabolism also show a higher riboflavin content. This conforms to the previously reported (6) relation between protein synthesis and riboflavin content in oats.

The list of vitamins of the "B-complex" now includes 7 known chemical compounds and the list is probably not complete. The application of some of the above-mentioned methods to the study of each of these factors in plants offers a field of fundamental and productive research.

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Papers in Chemistry

From the Report of the Section Chairman

The Chemistry program carried 11 papers, 8 of which are herewith published. The others were:

Garvey, N. F., Supervisor Visual Aids, University of Illinois, Urbana, Illinois. *Review of 1940-41 movies useful in the teaching of physical science.*

McLain, M. H., Wilson Junior College, Chicago, Illinois. *Review of 1940-41 texts for teaching of chemistry in first two years of college.*

Van Arsdell, Prudence, and Gustav Egloff, Universal Oil Products Co., Chicago, Illinois, *Nomenclature of cyclic hydrocarbons.*

Forty-five attended the meeting and elected as chairman for the Jacksonville meeting May 7-8, 1943, H. W. Gould, Northern Illinois State Teachers College, DeKalb, Illinois.

(Signed) N. D. Cheronis, *Chairman*

NEW ACID-BASE TERMINOLOGY

C. W. Bennett

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The last twenty years have seen a rather amazing change in the meaning of the terms acid and base for those who try to keep up with new developments. The following summary of the more important proposals will show that the meaning of the terms become more and more inclusive.

a) Arrhenius 1887—Hydrogen ion donor in water.
b) Brönsted 1923—Proton (H^+ ion) donor in general.
c) Germann 1925 — Solvent-cation donor.
d) Lewis 1923 and 1938—Electron-pair acceptor.
e) Sidgwick 1927—"Acceptor" for same idea as Lewis.
f) Usanovich 1939—More inclusive—electrophile.

The Journal of Chemical Education has published many articles concerning the new ideas and has recently reprinted a very valuable selection of them in book form.[1] To me the ideas of G. N. Lewis[2] seem most reasonable. Usanovich's acids include almost everything, Lewis' acids, oxidizing agents and other substances while the Brönsted theory is forced to omit some real acids like SO_3 and $SnCl_4$. Lewis defines an acid as "a molecule, ion, or radical capable of accepting a pair of electrons furnished by some other element or group. Conversely, a base is a structure which can furnish such an electron pair."

Many felt at first that the new ideas were all right if only new names were applied. Sidgwick,[3] for example, calls the Lewis acids "acceptors" and the bases "donors." Lewis, however is rapidly gaining support and the logic of his position is asserting itself.

When one considers the classical connotation of the word "base," it is hard to see how it could be the foundation of anything but the new usage makes it the base or foundation of an acid. The word "acid" means sour and that is generally true of Lewis' "acids." All the classical acid radicals as well as some other entities are called bases by the new system. Thus the acetate ion is the base of $HC_2H_3O_2$. Acids or bases may be cations, neutral molecules, or anions as the following examples will show:

ACIDS (Electron-pair Acceptors)

Cations	*Molecules*	*Anions*
H_3O^+	HCl	$H_2PO_4^-$
NH_4^+	$HC_2H_3O_2$	HPO_4^{--}
Zn^{++}	$SnCl_4$	$HC_2O_4^-$
Ag^+	H_2O	HSO_4^-
Fe^{+++}	H_3PO_4	
Al^{+++}	SO_2	
Mg^{++}	$HAlO_2$	
Cr^{+++}	SO_3	

BASES (Electron-pair Donors)

Cations	*Molecules*	*Anions*
$Zn(OH)^+$	H_2O	OH^-
$Al(OH)^{++}$	NH_3	PO_4^{---}
AlO^+	$Al(OH)_3$	HPO_4^{--}
$Fe(OH)^{++}$	NH_2OH	$H_2PO_4^-$
$Fe(OH)_2^+$		CN^-
FeO^+		$C_2H_3O_2^-$
		SO_4^{--}
		HSO_4^-
		O^{--}

Those which occur in both lists would be called amphiprotic (since the words amphoteric and ampholytic are now obsolete). Perhaps the most striking constrast is in the classical use of the word "bases" in Soil Chemistry and qualitative analysis for cations and "acids" for anions. The new theory makes most of these same cations "acids" and the anions "bases." Thus Zn^{++}, Al^{+++}, Fe^{+++} have long been called bases but their solutions taste sour, turn litmus red and have other characteristics of acids, alum even being substituted for the acid in cheap baking powder. Modern ideas are therefore more realistic.

Again, solutions containing such ions as CN^-, $C_2H_3O_2^-$, SiO_3^{--}, S^{--}, SH^-, CO_3^{--} and OH^- have a distinct basic reaction, yet some older books, especially qualitative texts, call them acids, including even OH^- by courtesy.

It would seem then, that at least for cations and anions, the new ideas are more logical than the classical. There is a feeling among many that somehow it is the Na^+ in NaOH that makes it a base. The new theory would say it is the OH^- which is the base and that the Na^+ is such a weak acid that it has practically no neutralizing effect upon the OH^-. Classical defenders will at once argue that NaOH is strong while $Zn(OH)_2$ is weak. They will say that this proves that the cation is what makes a base. The answer is that the cation *is* important but not in the way they thought. The Zn^{++} is a stronger *acid* than the practically neutral Na^+, and so partly neutralizes or minimizes the effect of the OH^-. This attitude, anyway, is no doubt a hangover from the confusion of a free element with its ion. While sodium is a very active element, the sodium ion is quite inactive, and it is this inactivity which allows the other ions of sodium compounds to exhibit their unhampered effects.

Now the Cl^- is a very weak base and practically neutral, while $C_2H_3O_2^-$ is a strong base. The molecule acid, HCl, is strong because Cl^- has little or no neutralizing effect upon the acid. $HC_2H_3O_2$ is weak because $C_2H_3O_2^-$ has a strong basic reaction and so reduces the acidity of the molecule.

The reaction between an acid and a base is not necessarily neutralization but can usually be fitted into the following scheme or a modification of it.

$$\begin{aligned} \text{Acid}_1 + \text{Base}_2 &\rightleftarrows \text{Acid}_2 + \text{Base}_1 \\ HCl + H_2O &\rightleftarrows H_3O^+ + Cl^- \\ H_3O^+ + OH^- &\rightleftarrows H_2O + H_2O \end{aligned}$$

The word salt is restricted to a substance which has an ionic lattice in the solid form and is completely ionized when fused or dissolved. Thus, Na^+Cl^-, Na^+OH^-, and $H_3O^+Cl^-$ are all salts but As_2S_3, $HgCl_2$ and $CdCl_2$ are excluded since the latter are practically un-ionized.

A classical "neutral salt" like Na^+Cl^- is a salt which *contains* the practically neutral weak acid Na^+ and the practically neutral weak base Cl^-. A classical "base" like Na^+OH^- is a salt which *contains* the weak acid Na^+ and the very strong base OH^-. $H_3O^+Cl^-$ is a salt which *contains* the strong acid, H_3O^+ and the practically neutral base Cl^-.

It is unreasonable to call Na^+OH^- a base and not a salt and refuse a similar classification to Na^+CN^-, $Na^+_2CO_3^{--}$, Na^+SH^-, $Na^+_2S^{--}$, $Na^+C_2H_3O_2^-$, $Na^+_2SiO_3^{--}$, etc., which are in some cases almost as basic in reaction. Furthermore, the dry, fused classical "salts" and "bases" will carry an electric current while pure classical "acids" in the liquid state will not carry a current unless an ionizing solvent is added. This shows that there is no fundamental difference between the first two classes which are now to be classed simply as salts, *containing* more or less active bases. The term "base" is thus released for a more fundamental meaning. Classical "acids" do not become salts, however, until they have reacted with an ionizing solvent. Thus HCl must react with H_2O, NH_3 or similar ionizing solvent to form an "onium" salt.

$$\begin{aligned} HCl + H_2O &\rightleftarrows H_3O^+ + Cl^- \\ HCl + NH_3 &\rightleftarrows NH_4^+ + Cl^- \end{aligned}$$

Types of Lewis Salts

Classical Salts	*"Onium" Salts*
Na^+Cl^-	$NH_4^+Cl^-$
$K^+NO_3^-$	$H_3O^+Cl^-$
$Ca^{++}SO_4^{--}$	$NH_4^+OH^-$
$Fe^{+++}Cl^-_3$	$H_3O^+HSO_4^-$
Classical Bases	*Not Salts*
Na^+OH^-	As_2S_3
K^+OH^-	$CdCl_2$
Li^+OH^-	$HgCl_2$
$Mg^{++}(OH^-)_2$	$Hg(CN)_2$

The more we consider these points, the more reasonable the new ideas become but one could wish that more texts and teachers had the daring to use them consistently. I look forward to the time when some department somewhere will start a generation of students right and use the new ideas entirely. I am afraid, however, that they would still have to be somewhat familiar with the classical ideas in order to be able to converse with the "barbarians" elsewhere.

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SEMIMICRO METHODS IN THE TEACHING OF CHEMISTRY

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The introduction of methods and technics permitting chemical experimentation with very small amounts was introduced about the first decade of the present century. The earliest uses of micro methods appears in biochemical and mineralogical investigations. In the detection of poisons it became necessary to develop tests using small amounts of materials and having high sensitivity. Also, as early as 1894, micro methods had been developed for the identification of a large number of minerals using in many cases a single crystal or 1 mg. of a substance were described. (1903.) The first microbalances were developed between 1909-1911. The work of Emich and Pregl during the early part of the century in the development of microchemical methods in quantitative organic analysis may be regarded as the beginning of a systematic growth in micro and semi-micro methods in chemical experimentation.

It was clearly recognized that the micro methods saved time and material, without sacrificing accuracy, provided the proper technics were used. Between 1925-1935, a few universities in this country introduced courses in microchemical quantitative organic analysis. One of the first introductions of the micro methods to undergraduate instruction was by E. C. Gray of Cairo, Egypt, who in 1925 developed a course in general chemistry. Though a manual was published, these methods did not take root in the teaching of general college and high school chemistry. The main reason is probably that these early attempts introduced actually micro methods, that is, the work involved a drop of the liquid, or a few milligrams of a solid. It was not until the micro methods were changed to semi-micro that they found a place in the college curriculum, in the teaching of Qualitative Analysis. Engelder at the University of Pittsburgh introduced such a course at about 1930 and published his first results in 1932. This marks the beginning of a rapid growth in the introduction of the semimicro methods to the teaching of Chemistry. Today about 75 per cent of the colleges and universities use the semimicro technic in the teaching of Qualitative Analysis.

Although the semimicro technic has been introduced widely in the teaching of qualitative analysis only limited progress has been done in the introduction of these methods in the teaching of general chemistry both at the college and high school level. As shown by the bibliography there have been a few attempts but the method has not yet taken root. The introduction of the semi-micro methods to the teaching of elementary organic chemistry did not start until recently. The difficulties in this field are much greater. Special glass equipment such as condensers and distillation flasks for handling small amounts had to be developed first before any of the traditional experiments can be adapted to the new technic.

The war has brought great demands for economy not only of materials but also of time; it seems therefore imperative that teachers should reexamine their disinclination to stray away from the easy beaten path of the tried and true traditional methods. The semi-micro technic for teaching sacrifices none of the objectives of any laboratory course in chemistry—and in addition offers a number of distinct advantages. On the basis of the experience of teachers who have worked with these methods the following advantages may be safely claimed: (1) The factual material of chemistry and the illustration of principals can be illustrated as well with 0.5 g. as with 10 g.; (2) Technics, cleanliness and accuracy are better and more highly developed by the micro methods than by the traditional micro methods; (3) A smaller initial investment for equipment and what is more important, less breakage and upkeep; (4) The student is enabled to do

a great deal more in the time available without sacrificing thoroughness; (5) The accident hazard is reduced; accidents become micro accidents; (6) The micro methods can be well adapted to develop the student's curiosity for self-development. The hobby of the "home laboratory" which is difficult or impossible with macro equipment not only can be encouraged but it can be used to greater advantages. The space needed at home is very small, with little or no fumes or odors. The following is a partial bibliography of micro and semi-micro methods for the teaching of chemistry.

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REVIEW OF RECENT CHEMISTRY TEXTS FOR USE IN THE TEACHING OF CHEMISTRY AT THE HIGH SCHOOL LEVEL

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In the consideration of recent textbooks in chemistry, I am reminded of a statement by Dr. Samuel Ralph Powers, regarding educational practices in general. He states that "practices in education are influenced by the condition of the times in which they are current and seem to represent a fusion resulting from conflict between apparent demands of an immediate and on-going social milieu and traditional procedures based upon supposed needs of the past!"[1] Examination of textbooks on the high school level reveals on one hand an obvious tendency to comply with the suggestions of modern educational procedure; on the other, a reluctance to break sharply with tradition. The observation is not intended as a criticism of publications in general, but as a statement of fact, as I see it. There is even a possibility of the condition persisting to the extent that the success of a textbook is measured in terms of volume of sale. If this is true, those attempting the production of a volume of material suitable to the needs of a course of instruction cannot be criticized too severely for an adaptation to an established practice—the manner in which work of this kind is approved, published, and accepted by the educational world.

One might be inclined to question whether or not there is cause for a certain devotion to the traditional methods of educational procedure; however, we do not have to search long to find evidence of it. Belting and Clevenger in *The High School At Work* remark . . . "though we live in a world of progress and change, tradition has spun its web around hundreds of our high schools so strongly that if one of the colonial schoolmasters could rise from his grave for a visit to them, he would feel quite at home."[2] Dr. Powers in the discussion mentioned above says, "There can be no doubt that science teachers in many schools have failed to keep adequately in touch with trends in education and with the social, economic, and political developments of the dynamic society of which they as individuals and as teachers are a part. This is obvious to anyone who will take the trouble to observe it."[3]

Regardless of the status of science instruction, the tendency of many textbooks to follow the trends of modern educational practice should do much to correct a condition that has long been ignored by those who are subject-matter minded.

In the main, the modern approach seems to stress certain factors: namely, the education of numbers, regardless of individual differences; less formal presentation with greater adaptation to social needs; consideration of economic principles, that is, the conservation and utilization of natural resources; care of health, physical and mental; a recognition of the educational value of activity; and the organization of information into units of instruction that can be integrated with material of other courses.[4]

With these factors in mind, I should like to consider the following features:

1. Philosophy: What is the book expected to teach? How is the objective to be attained?
2. Mechanics: A. Basic organization. B. Outward appearance, dimensions, and construction. C. Size and clearness of print. Readableness of material. D. Number and quality of diagrams, photographs, and other illustrative materials.
3. Content Materials: A. Chemical principles, theories and laws. B. Discussion materials. C. Descriptive materials. D. Contributions of chemistry to science. E. Glossary of terms, tabular material, and appendices.
4. Learning Materials: A. Research activities and projects. B. Use of knowledge

[1] Powers, Samuel Ralph: "Preparations of Science Teachers to Contribute to General Education"; *School Science and Mathematics*, April, 1942, p. 315.
[2] Belting and Clevenger, *"The High School at Work,"* Chapter II, p. 19.
[3] Powers, op. cit., p. 317.
[4] Adapted from Powers, op. cit., pp. 316-17.

gained. C. Development of ideas and principles. D. Topics for investigation. E. Unit recitation and tests. F. Supplementary exercises.

5. Teaching Aids: A. Films. B. Film strips. C. Slides. D. Posters. E. Displays. F. Free teaching aids.
6. Evaluation: A. Methods for testing ability to think reflectively. B. Methods for testing ability to use the scientific method.

I should like to discuss, first, the texts of recent copyright still organized on the topical plan. In this group I have selected the following:

1. *New World of Chemistry*, by Bernard Jaffe; Silver Burdett Company, Chicago, 1941.
2. *Chemistry and Its Wonders*, by Oscar L. Brauer; American Book Company, 1938.
3. *First Principles of Chemistry*, by Brownlee. Fuller, Hancock, Sohon, and Whitsit; Allyn and Bacon, Chicago, 1940.
4. *General Elementary Chemistry*, by John C. Hogg and Charles L. Bickel; D. Van Nostrand Company, New York, 1941.

New World Of Chemistry seeks to develop well informed, intelligent individuals, capable of complete adjustment to life situations. Furthermore, it seeks to impress students with the importance of science, and to create a desire for use of the scientific method. The book is attractive in design. The type is of moderate size, and clear. Diagrams, photographs, and murals are clear and abundant. They are well chosen and contribute much to a general theme, that is, the role of science in the development of civilization. Although there are a large number of chapters, the sequence is good. The language is simple and clear. Technical terms are made intelligible to the student. Chemical principles are carefully developed, and the illustrative materials are compact. At the close of chapters there is a brief list of selected readings; a summary of useful ideas developed; two groups of review questions—the second brief, but sufficiently difficult to challenge the stronger students. Also, there are suggested activities, projects and investigations. In addition to a development of chemical principles, there is direct effort to impress students with the importance of learning, and the values of the scientific approach. The work is inclusive, in that it treats the earliest developments, and also modern contributions. It suffers somewhat from traditional organization.

Chemistry And Its Wonders is intended to contribute to the general culture of the individual. An extreme effort is made to show the relation of chemistry to life. The book is attractive; however, it is slightly cumbersome for ordinary use. The type is large, clear, and the material is very easy to read. Photographs and diagrams are numerous and appropriate, the latter being particularly illustrative. The reading material is interspersed with simple experiments to be demonstrated by the instructor. At the close of chapters and at appropriate places within chapters there are numerous review questions. The questions are designed to review scientific facts and to aid in understanding principles developed. Additional exercises for superior students, and supplementary reading lists, compensate in part for a lack of formal data. Some of the later chapters—Chemistry and Health, How Chemistry Helps the Doctor, The Chemistry of Cooking, Chemistry and Transportation, The Chemistry of Common Things—indicate the general purpose of the work. The book is an excellent reference, but it is scarcely adequate as a textbook for ordinary high-school work.

Elementary General Chemistry is strictly traditional chemistry. The book is plain in design, and organization. No particular philosophy is expressed by the authors. The numerous chapters close with a few questions on factual data. There is an occasional summary, and an occasional list of practice problems. At the close of the book there is an adequate list of supplementary readings; also, some review questions. Few of the questions provoke thought, nor do they test ability to use chemistry in a practical way. The book is designed to serve the needs of schools having one or two years of chemistry. I doubt if it would serve either very well.

First Principles Of Chemistry is a book that has enjoyed a wide usage. The authors were among the first to break sharply with tradition. Although the copyright lists three revisions since the 1931 edition was published, the book is sadly out of date. Compared with some recent publications, the book is not particularly attractive. It is lacking in photographs and illustrative materials. There are numerous learning exercises within chapters and at the close of chapters. Also, there are four general tests, designed to cover certain sections of the book. The summaries at the close of chapters deal with facts only. There is no provision for individual differences,

no projects are suggested, and no suggestions are made for supplementary readings. A satisfactory revision of the book is long overdue. (I understand the work is in progress.)

The second group of books considered are organized on the unit plan. I have selected the following for consideration:

1. *Modern Life Chemistry*, by Kruh, Carleton and Carpenter; J. B. Lippincott, Chicago, 1941.
2. *Chemistry and You*, by Hopkins, Davis, Smith, McGill, and Bradbury; Lyons and Carnahan, Chicago, 1939.
3. *Chemistry at Work*, by McPherson, Henderson, and Fowler; Ginn and Company, Chicago, 1938.

Modern Life Chemistry is based upon the philosophy that the individual is of prime importance. It is desired that the course of instruction will benefit the individual in a personal and social manner. The book is attractive, modern, and well organized. The diagrams and photographs are numerous, but many are not clear. The careless design of many diagrams constitutes a serious defect, in an otherwise very creditable publication. Numerous charts and tables have been used to good advantage. The book consists of eleven units; a number of discussions concerning contributions of modern chemistry; an appendix of useful materials; and a long list of supplementary references. Five of the units in the earlier part of the book deal with the fundamentals of chemistry. Six units in the latter part of the book deal with chemistry as it is used in a practical way. Each unit is organized about a basic idea, or principle. The units are broken down into specific contributory problems. All units and all problems have a definite assignment. Following the problem assignment is a presentation of subject matter and a list of summary exercises for all students. At the close of the units there are optional exercises, problems, and topics for investigation. Also, a unit recitation and test dealing with topics for oral or written recitation. The theory of the book is that knowledge alone is insufficient; the student must be trained to use the scientific method. The materials and organization of the book are well adapted to this end.

Chemistry And You is based upon the theory that individuals are constantly confronted with new problems. For this reason the students should learn to solve problems as they appear. In order that they may be able to do so, they must learn to use the scientific method. The learning materials are adapted to this end. This is an attractive book. The print is small, however clear; the diagrams are not numerous, but they are adequate, and clear in design; photographs are few in number, but good. There are sixteen units in the book. The units are developed about fundamental principles and generalizations. Units open with a preliminary discussion. Major problems are suggested by means of specific questions. At the close of the assimilative material bearing on the problems, two or three appropriate readings are suggested. Also, there are suggestions for the application and use of chemistry. Research activities are given to stimulate continued study. At the close of the unit a comprehensive summarizing test is provided. It is followed by a discussion review. Attention is focused upon economic principles, through extensive units dealing with health, natural resources, and metals. An extensive list of supplementary readings is provided in the preface of the text. The content materials are well adjusted to the development of problem solving abilities.

Chemistry At Work is intended to teach students that science is the result of careful observation and experimentation; careful formulation of theories and laws; and that the body of knowledge is constantly growing. Furthermore, it is suggested that the material should be interesting, and as practical as possible. The book is attractive, and of good construction. While slightly larger than the average book, the dimensions are not objectionable. The print is of moderate size, and clear. The material is easy to read. Diagrams and photographs are numerous and generally good. The fourteen units in *Chemistry At Work* are broken down into chapters. Chapters are headed by a preliminary discussion. At the close there is a summary in question form. Also, numerous thought questions and optional exercises are provided. At the close of units an extensive list of supplementary exercises is given. Apparently, the authors do not feel that the student is of first importance. Contents of the book reveal a considerable respect for science as an end in itself.

Conclusions.—Practically all of the books mentioned are written on a secondary level and may be adjusted to the

needs of the average student. In most cases there is an increasing tendency to stress individual and social needs as well as factual data.

Three of the books: *Modern Life Chemistry, New World Of Chemistry,* and *Chemistry And You,* provide an abundance of learning materials, thus indicating a profound belief in the educational value of activity.

None of the books make suggestions concerning visual aids in the form of films, film strips, slides, posters, and free teaching aids.

No provision is made to evaluate progress made in the effort to employ reflective thinking, or to learn the use of the scientific method. There is urgent need for means and methods of measuring progress.

Often the teacher is reminded that instruction is of little value unless it becomes functional. In reply, the instructor asks, "How can it be made functional?" It is my sincere belief that the authors of *Modern Life Chemistry, New World Of Chemistry,* and *Chemistry And You* have done much to answer the question.

NEW SOURCES OF MINERAL ELEMENTS IN ANIMAL NUTRITION

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Introduction.—In the national war effort, many scarce and necessary materials have been designated as "strategic materials." Among these are certain metals of nutritional importance which are called "trace elements" in nutrition and which are essential to animal life. They overcome some "hidden hungers," and it is therefore important under many conditions of livestock feeding to supply available sources of these elements.

Manganese, cobalt, and copper are among the most important of these elements. Manganese in the form of a soluble salt is now included in the majority of poultry feeds to prevent perosis or slipped tendons and to improve egg production and hatchability of the egg. It also prevents certain types of lameness in pigs according to recent work from the Pennsylvania Agricultural Experiment Station.

The element cobalt is lacking in the soils and vegetation of many regions of the world. In this country, such cobalt deficient areas are found in Florida, Texas, Michigan, and other regions. Cobalt is necessary for the normal nutrition of domestic animals, particularly cattle and sheep, and a deficiency produces a typical anemia which may be very severe and result in great economic loss.

Copper is known to be necessary for the building of the hemoglobin of the blood and for the utilization of iron in the body. A copper deficiency has been demonstrated in the soils of Florida, and it has been shown that the administration of copper compounds to livestock has given remarkable results.

All of these elements are commonly supplied in livestock feeds in the form of soluble salts such as the sulphates. Since these salts have become "strategic materials," it has become important to investigate non-strategic substitutes such as the crude ores and other unrefined forms of these metals.

Experimental.—The experimental procedure has been as follows:

First, to locate deposits of ores and other impure sources of the metal in question; second, to analyze for the elements desired and also for any toxic materials; third, to determine the availability to the animal of each source; and, fourth, when the form was found non-assimilable, to devise treatments to increase its assimilation by the animal.

The investigations have covered manganese ores from Tennessee, Arkansas, and Missouri, cobalt ores and impure concentrates from Missouri, Nevada, Arizona, and Oregon, and copper ores from Missouri, Nevada, and New Mexico. The analysis of these ores varied widely, and, in a few instances, ores have been found unsuitable for further study because of toxic impurities such as lead.

Manganese.—A typical experiment on the availability of manganese ore in-

volved the use of young chicks on a perosis-producing ration, which was high in phosphorus and low in manganese. Five lots of twenty chicks each were fed for six weeks on the experimental rations and the incidence of perosis observed. Supplying fifty parts per million of manganese in the form of a Tennessee ore or an Arkansas ore, or even one hundred parts per million as the Arkansas ore, failed to give protection against perosis. The results were no better than in the lot receiving no manganese. On the other hand, fifty parts per million of manganese in the form of manganese sulphate protected all but one bird.

Schaible and his co-workers at Michigan State College reported good utilization of numerous manganese ores, including oxide ores. Tennessee and Arkansas ores studied in our laboratory were stated by the producers to be oxide ores. The findings reported therefore do not agree with those of Schaible.

Laboratory investigations show that the manganese ores are made soluble and thus available by a simple treatment with hydrochloric or sulphuric acid.

Cobalt.—The availability of cobalt to the animal was determined with rats by the production of a polycythemia or increase above normal in the red cell count and hemoglobin content of the blood. Groups of rats on a mineralized milk ration and receiving cobalt at the rate of 0.6 of a milligram per rat per day showed a marked rise in hemoglobin with cobalt sulphate but only a slight response to the cobalt in a Missouri ore or crude cobalt oxide.

The method used may be open to question, since cobalt in these ore forms might be utilized by an animal in need of it, where as it might not be effective in stimulating the hemoglobin to abnormally high levels. Nevertheless, it furnishes a basis of comparison of the relative availability of cobalt sources.

Preliminary laboratory treatments of cobalt ores have indicated that at least partial availability may be achieved by relatively simple acid treatments.

Copper.—The availability of copper compounds was studied with young albino rats made anemic by the method of Elvehjem, using dried whole milk. Rapid hemoglobin regeneration was produced by 0.03 of a milligram per rat per day of copper in the form of copper sulphate or of a copper carbonate ore from Arizona; however, the copper in a copper sudfide ore from Nevada produced no greater recovery from the copper anemia than did iron alone in the negative control group.

Conclusion.—Much more work needs to be done, but this progress report shows that it is entirely feasible, by the use of such methods as those described, to develop new sources of the trace elements suitable for animal feeding and thus conserve the pure metallic salts.

WHAT THE COLLEGES OF ILLINOIS ARE DOING FOR NATIONAL DEFENSE

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The accompanying table furnishes a general picture of the ways in which the colleges and universities of Illinois are cooperating with the war program. The picture, however, is not complete. There is no report from some 14 other colleges where war-connected activities are likely in progress. Also most of the schools which have reported are carrying on a variety of activities hardly classifiable under the general heads chosen.

As may be expected the three larger universities of the State, also the technical and engineering schools, have been carrying on large war-connected programs for some time. Also the universities in particular have supplied many staff members for technical and confidential governmental research. Research work for the branches of the military service is now being engaged in actively by teaching and research staff members. Both on and off campus the University of Chicago estimates that 80 per cent of all research now carried on is specifically directed toward some war end, 232 members being so engaged. Here at the University of Illinois the department of physics has granted leaves to Professor Loomis, the head of the department and to 6 of its principal men to carry on a highly technical program of research in the East, all of which has been in progress for over a year. Also the department of chemistry at Illinois has a number of men similarly engaged on very important research projects related to the war for various departments of the government. Professor Roger Adams is now serving as chairman of division B (chemistry and chemical engineering) of the National Defense Research Committee. In addition to such service as this, the Universities have furnished a large number of staff members and students who have gone into military service, most of them as volunteers. Northwestern University reports 43 faculty men and 161 students plus an additional 42 men scheduled to leave with the hospital unit number 12, February 15.

Most of the military units are in the universities only, such as R. O. T. C., Signal Corps, Coast Guard, Meteorological Institute (at Chicago, one of five in U. S.) and Naval Aviation. However, it is to be noted that an R. O. T. C. Unit has been functioning in Knox College for some time, also a volunteer unit using the R. O. T. C. manual has been working at Shurtleff College which is near Western Military Academy also in Alton, Illinois. Also training with sea planes is in progress at Carthage College. Civilian pilot training is or has been carried on in many of our small colleges. The Bradley Polytechnic Institute, have had a ground school and flight training program in operation for some time.

War time courses of one kind or another are to be found in practically all of the colleges. It should be pointed out in this connection that the elementary courses in physics, chemistry and mathematics which have long been a part of the regular curricula furnish very valuable background training for all branches of the military service. ESMDT courses have been offered in profusion by the universities and many of the technical schools. These courses are offered either on the campus of the institution where they are organized or are given as extension courses in surrounding areas, such extension courses being in charge of industrial trained men or instructors in nearby colleges. At the University of Illinois, for example, there are now 24 such extension courses involving a total enrollment of 3,600 students. These courses are taught in centers distributed throughout the State. Other courses are in process of being organized. At Northwestern University there are 24 ESMDT courses with an enrollment of 1,500; at the University of Chicago there are 18 courses with an enrollment of 1,100. At Bradley Polytech there are 900 stu-

dents at present enrolled in ESMDT courses, also there are 1,500 students enrolled in a separate vocational industrial program. It is expected that next year a 24-hr. round schedule will be in operation. At Illinois institute of technology there are 60 courses now being taught with such typical enrollments as 30 or 40 per course. It is noteworthy to note that at this Institution courses are being organized for training women for the industrial plants in the Chicago area. At Shurtleff College there are 18 ESMDT courses with a total enrollment of 600. All courses of this kind are for the most part non-credit courses taught by instructors in many cases at night or out of class hours as overtime, and are taught to students outside the regular college or university enrollment. It would appear that this total program of courses, pointed towards training for specific war aims, represents the greatest single contribution that the colleges and universities are making toward the war-preparedness program.

There are a number of courses that are either regularly taught in the curriculum or have been recently added which are of distinct service to the war program as, for example, radio, electronics, meteorology, and navigation. Of particular interest is a three-year radio course now organized in the physics department at Eastern Illinois Teachers College at Charleston. This course is being offered at the expense of certain other courses dropped temporarily from the physics major.

There are many other ways in which the colleges are contributing to the war program, as for example, the Southern State Teachers College at Carbondale. The college has loaned to the community for half-time duty, a director of the Civilian Defense Council, also another for coordinator of War Activities in the area acting as liaison officer between the different civic and political organizations in the area and the local ordinance plant. Another member of the faculty is chairman of the rationing board; still another a member of the local draft board. Similar contacts have been reported in other colleges.

In many cases where a college is near an industrial or war-production plant various mutually beneficial contacts have been established. Members of the college staff may serve in advisory capacities for plant operations or men in the plant may serve as instructors in vocational or in ESMDT courses at the college. Modified credit courses may be offered which are pointed directly towards the training of students for work in the local plant and many of the graduates and undergraduates go into the plant as civil service inspectors, etc.

A summary of activities on our local campus will serve as typical illustration of what has gone on apparently in most of the colleges of the State. For the past year a college defense committee has been developing possibilities for war connected activities in which the College could function. A regular College representative has also been appointed to serve as general liaison officer between the College and surrounding areas. Under this set-up the following things have developed or are in process of development. (1) A committee on Civilian Morale has administered a program of training dis cussion leaders. Up to now these leadership training programs have been set up in 25 centers serving about 900 persons. The materials used at these meetings have been endorsed by the U. S. Office of Education. Requests for them have come from Western Teachers College, University of Illinois, University of Kansas, and Columbia University. (2) The College was one of the first to be accepted for the V-1 program. (3) A plan with the Great Lakes Naval Training Station under which groups of 300 men are to be sent to the campus for training periods is under consideration. (4) Several special courses are being carried on or are being arranged. (a) Visual Education materials (University of Illinois, supervision) (b) First Aid (c) Public health and Sanitation (University of Illinois) (d) Fundamentals of Radio (ESMDT) (e) Foundations of Engineering (ESMDT) (f) Lathe Practice and Map reading. (5) The Social Science Department has conducted a winter series of lectures and forums for the past several years. This year this Department has brought in other members of the faculty for discussions of topics pertinent to the war emergency. (6) The college has cooperated with the local town officials in the promotion of trial blackouts, also in an air raid warden emergency course.

TABLE I

School	Civilian Morale Program	R.O.T.C. V-1 C.P.T.	Other Military Units	E.S.M.D.T. Affiliation Vocational	New or Modified Courses	Phys. Ed. Program Increased	Accelerated Schedule
1. University of Chicago	yes	1000 V-1 yes	Signal Meteor. Coast G.	18q(1100)	yes	yes	4 quarters
2. University of Illinois	yes	4243 V-1 yes	Signal Exptl.	24 (3600) others	yes		3 semesters
3. Northwestern Univ	yes	Naval V-1-7 yes	Nurses Train.	24 (1500)	yes		4 quarters
4. Augustana		C.P.T.			10 sect.		
5. Bradley Poly Tech		V-1-5-7 C.A.A.		(900) (1500) 24-hr. Sch.			year-round
6. Carthage	yes	V-1 Sea Plane			3 sect.		
7. Eureka					2-yr. Sci. Schedule		6 8-wk. terms (single units)
8. Illinois Inst. Tech				60 Courses	Courses for Women in Industry		
9. Illinois Teachers Carbondale	yes	V-1 C.P.T.		5 sect.			4 quarters
10. Illinois Teachers Charleston	yes			7 sect.	3-yr. Radio Course		4 quarters
11. Illinois Teachers DeKalb	15 centers	V-1 Navy Plan		2 (planned) 1 (planned)			8 wks. summer
12. Illinois Teachers Normal		V-1 C.P.T.		yes			
13. Knox	yes	R.O.T.C. C.P.T.			yes	Calisthenics yes	
14. Lake Forest	Pre	Ind. Plan V-1			yes		
15. MacMurray					4 sect.		8 wks. summer
16. North Park	yes	V-1			2 sect.	yes	
17. Quincy Jr. College	yes	C.A.A.			First Aid		
18. Shurtleff		V-1 C.A.A.	Volunteer Unit	18 (600)			
19. Springfield Jr	yes	V-1 Cadet Air Corps			3 sect.		12 wks. summer for premedics
20. St. Francis	yes				7 (350) First Aid		
21. St. Xavier	yes				yes		
22. Wright Jr	yes	V-1 Army Plan			4 sect. Others Planned		

It has also carried on selective service registrations and sugar rationing.

Accelerated schedules have been adopted in several schools. This has taken several forms as shown in the table. Some schools, the University of Chicago for example, have been offering eleven to twelve weeks of summer sessions made up of two terms and are continuing to do so. Others which have offered no summer work before are doing so now, at least in some subjects. Others

are extending their summer session say from six to eight weeks (MacMurray College) or from eight to twelve weeks or an entire semester as the University of Illinois and some of the teachers colleges are doing. Others, like Bradley Polytechnic Institute are putting on a continuous year-round schedule, eliminating the usual holiday vacations. In this connection there is difference of opinion as to the efficiency of an unbroken teaching period of several months duration.

It would appear from this brief survey that the institutions of Illinois, over and above their ordinary programs, are doing a fair share in helping to train personnel for this highly mechanistic war.

DEMONSTRATION OF UNSTABLE ANIONIC COMPLEX FORMATION BY THE METHOD OF ELECTROMETRIC TITRATION

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Although the pH value at which the precipitation of a given hydrous oxide or hydroxide occurs is in general independent of the type of anion present, in those instances where the anion is capable of coordinating with the cation, the concentration of the latter may be reduced to such an extent that excessive quantities of alkali must be added to induce precipitation. In other words under these conditions the precipitation pH is appreciably raised, and in instances where the complex is either inherently sufficiently stable or is stabilized by excessive quantities of the added anion, precipitation can be completely inhibited.

Thus it has been demonstrated (1, 2) that not only can the precipitation of hydrous mercuric oxide be completely inhibited by added chloride, bromide, or iodide but also that the dry oxide can itself be dissolved in solutions of the potassium halides with the quantitative liberation of titratable potassium hydroxide. Similar phenomena are encountered with the corresponding cadmium materials (3) although the lesser stabilities of the cadmium complexes necessitate the presence of excessively high quantities of the potassium halides to prevent the precipitation of the hydrous hydroxide.

The effects of anionic complex formation upon subsequent hydroxide precipitation can be readily followed by an electrometric titration technique which involves treatment of the salt solution in question with successive increments of standard alkali, the changes in pH being followed by means of a suitable glass, quinhydrone, or hydrogen electrode assembly. Displacement of the resultant titration curve toward higher pH values can then be taken as being indicative of complex formation, and the instability of the complex is shown not only by the magnitude of the pH displacement but by the similarity existing between the displaced curve and the normal curve for the uncomplexed cation. Procedures of this sort do not, however, give information as to the structures of any complexes which may arise.

Thus when solutions of such strong electrolytes as lanthanum bromide and neodymium chloride are titrated with alkali in the presence of successively increasing quantities of alkali bromide and chloride respectively, the titration curves show no displacement from those obtained with the pure salts alone even at such high ratios of alkali halide to rare earth halide as one hundred twenty to one. These not unexpected results indicate the complete lack of coordination between the halide and rare earth ions by proving that the concentrations of the lanthanum and neodymium ions are unaffected by added halide.

With the elements immediately following the transition elements in the periodic system, however, anionic complex formation is commonplace as is indicated by the poor conductivities of many of the salt solutions (particularly those of the soluble halides). Thus the inhibitions of oxide and hydroxide formation is mercuric and cadmium salt solutions containing added halides can be

ascribed to the formation of complex anions of the form $[MX_4]^=$ in accordance with the coordination number of four usually exhibited by these elements.

The method of electrometric titration could readily be extended to studies upon the effects upon hydroxide precipitation exerted by similar complexes of many of the elements in this general region of the periodic arrangement. Such an element is indium, halo complexes of which have been indicated by various other methods.

Alkali titrations of indium salt solutions containing added alkali salts indicate displacements of the precipitation regions of the titration curves to higher and higher pH values in the series iodide to bromide to chloride to fluoride, the fluoride thus giving the most stable complex. The weakly coordinating nitrate ion has no effect when added, but the sulfate raises the precipitation region somewhat farther than does the chloride.

That the resultant indium complexes are sufficiently unstable (except with the fluoride) to effect only slight reductions in indium ion concentration is apparent from the fact that only at halide to indium ratios of around one hundred to one do curve displacements become appreciable. Precipitation of hydrous indium hydroxide is completely inhibited by none of these anions, probably because of the instabilities of the complexes and of the fact that the precipitation pH of the hydroxide is so low at 3.41 (4) that an extremely large pH shift would be necessary.

Inasmuch as the coordination number of indium in its compounds is generally six, anionic complex formation can be regarded as resulting according to the equilibrium

$$[In(H_2O)_6]^{+++} + 6X^- \rightleftarrows [InX_6]^{\equiv} + 6H_2O$$

That the equilibrium constants for the reactions in question are small is attested by the excessively large amounts of X^- needed to bring about effective equilibrium displacements.

The stabilities of halo anions in general are functions of both the cation and the anion. Thus the order of decreasing stability runs from iodide to fluoride with the members of the "B" families of Periodic Groups I and II but from the fluoride to the iodide in Groups III and IV. The smaller ionic radii of the members of the latter two groups apparently offset the tendency of the more covalent iodide to enter into such complex formation.

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SUITABLE CURRICULA FOR HIGH SCHOOL CHEMISTRY

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Since hypothetical considerations on curricula for High School Chemistry have been discussed so frequently and so thoroughly, it mounts almost to the height of the ridiculous to break down and build up once more, with the hope of attaining anything like the ideal.

High School Curricula as viewed in this paper cover the well known accepted line: First, General Chemistry; Second, College Entrance Equivalent; Third, Popular Course; Fourth, General Science. These have their various advantages and disadvantages.

Because of these apparent advantages and disadvantages a rapid summary will be sufficient to bring them to our attention. First, General Chemistry is an encyclopedic description of practically the entire field. This is found successful with students who have carried two to three years of science or those who have the ability to do scientific thinking. On the other hand students who have had but one year of science or no previous training would perhaps lose all enthusiasm or never develop an inclination towards chemical viewpoints.

Second, the College Entrance Equivalent, is the course that should enable the student after entrance examination, to register in Analytical Chemistry or carry a condensed course in General Chemistry. It is recognized in many colleges that this course is sufficient preparation for Analytical Chemistry. However, many college freshmen find the following difficulties: (A) they are not as yet orientated into college; (B) they do not think with adult scientific minds; (C) the ebulition of High School Chemistry has ceased.

Third, the Popular Course in Chemistry and fourth, the General Science Course should develop a scientific attitude of mind, and the ability to do critical thinking, and should serve as vocational guidance courses for the scientifically minded.

Estimating these courses from the teacher's platform, his adequacy and inadequacy of preparation comes to the fore. The following appears in the Illinois Bulletin No. 8, 1940, concerning preparation of teachers in Physical Sciences, effective in Illinois High Schools: In the field of Physical Sciences sixteen hours are required, in the subject ten hours. Is this preparation adequate? Yes, if as a student, the teacher in question had developed the two concepts (critical thinking, and a scientific attitude of mind) and can stimulate a critical attitude and an appreciation of science. Adversely many with stereotyped preparation never get beyond a mechanical presentation of the subject.

The nucleus of this paper is to discuss the fact that the ideal course in High School Chemistry should be given primarily to incite stimulation. (This stimulating course would act as a sounding-board to test the student's aptitude for Chemistry.) Also the General Inorganic Course taken in the college is practically indispensable for the Chemistry Major.

The advantages of the above suggestions may be listed:—a) This would give all entrance students relative mental aptitudes—their orientation and tools with which to begin their major work would lie in the same plane; b) with this average requirement of knowledge, enthusiasm would not suffer; c) presentation of theory in High School Chemistry should be subservient to practical application. This inductive method, broadens instead of cramps the student's ability to do creative thinking; d) an elaboration of theory if not accompanied by thorough understanding and sufficient practical application, stifles scientific interest and progress; e) an elaboration of theory accompanied by thorough understanding creates a superiority complex with regard to the student's idea of his knowledge of Chemistry; this has a disintegrating effect which is practically irrevocable; f) it is almost impossible to introduce into High School a course that will be equivalent to a General Inorganic Course as

given in college; this means that the student with the General Inorganic Course that is supposed to be College equivalent, has inadequate background for major study in Chemistry.

What would be the ideal course in High School Chemistry? These would no doubt amount to courses, and would differ according to the type of high school. In an academy for girls where the majority will be Home Economics majors or technicians the practical applications can be directed in those fields. In a boy's high school industrial and special professional fields may be considered, whereas in the co-ed high school, a varied course would be advisable, one having general application. Such a course would be one that would accompany the laboratory manual, "Test It Yourself" published by Scott Foresman.

A great objection to the above suggestions is the well-worn fear that Chemistry majors will be retarded if they are not able to step into courses in Analytical Chemistry as soon as entering college. There are other time saving devices which would not nip the scientific bud. Cannot the High School equip the student so well in fundamentals of rhetoric, history, languages, that these can be eliminated in college by proficiency examinations? This would afford more hours in the major field.

May I be pardoned for referring to personal observations and experiences? In the teaching of High School Chemistry for nine years, I have noticed that: a) much of the truly theoretical material is beyond the grasp of the majority, therefore presentation is cramped; b) the time element being limited, presentation of extensive theoretical or practical applications must suffer in assimilation; c) whether they be potential Chemistry majors or not emphasis on the practical will leave all students with a fair understanding of everyday Chemistry; d) for potential Chemistry majors, practical Chemistry gives them a background which broadens their concepts to the fact that theory without application is like a soul without a body, rather ghostly.

Carrying this knowledge into the teaching of six years of Freshmen College Chemistry, the following points have come to my attention through observation and interviewing of students who have had Chemistry before entering college: a) decided superiority complex: b) waning of interest; c) class morale disintegration; d) fallacy in theoretical knowledge.

As a closing question: If these suggestions made in this paper are valuable to our future Chemists, can we do anything about them?

THE ROLE OF THE CHEMISTRY TEACHER IN NATIONAL DEFENSE

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Fear has been expressed in certain quarters that a sense of frustration might develop in the minds of chemistry teachers because of their inability to take an active part in the war effort. Before Pearl Harbor, we were always speaking of our defense effort. Slowly, since December 7th, there has been a distinct change from a spirit of defense to a spirit of offense. We are hearing less and less of the necessity of purchasing defense stamps and bonds, and more and more of the privilege of purchasing war stamps and bonds to sustain our *offensive effort.* Slowly the nation is beginning to gain a better conception of the magnitude of the war effort and to realize that we have a home front as well as the battle front. In this home front the chemistry teacher can perform a very important role.

We are beginning to realize that this is "total war". In 1937 it seemed incredible to all of us that it was a crime in Germany to discard an empty toothpaste tube. But now we find that we cannot purchase a tube of toothpaste unless we turn in an empty tube. This typifies the meaning of total war. Successful prosecution of the war requires correlation of effort between the home front and the battle front. One of the important functions of the home front is the battle of production—munitions, tanks, planes, ships, fuel, and hundreds of other items needed in quantities never dreamed of before. We have become the principal arsenal of all the United Nations. The enemy can be expected to do everything in its power to disorganize our home front. This is not the place to discuss the possibility or probability of assaults by air with incendiaries, high explosive bombs and gas in the interior of this nation. The attack on Pearl Harbor was not thought possible, but it did occur. Before January 1st, no one would have thought it possible for Germany to sink one or two ships a day on our side of the Atlantic. But it has been done. Our army and navy authorities point out that a bombing of industrial centers in Illinois can be expected. The great circle route from Norway to Chicago is about the same distance as that from Germany to New York. However, the chances of detection of enemy bombers over this route would be very small because most of the route lies over uninhabited forest region in Canada. The objective of such a bombing, of course, would be to demoralize the civilian population and to hamper production. Especially in densely populated manufacturing areas, our government wishes that all citizens should have some instruction in the nature of high explosive and incendiary bombs, that they might know what to expect and what to do in case of bomb and gas attacks. A bombing with ten medium size bombers might start as many as 1500 fires in the congested area of a large city. The only way to combat this kind of an attack is with a trained citizenry.

The training of citizens in proper blackout methods and the proper procedure to follow in case of gas, fire and air attack involves problems in the selection and training of personnel in which the chemist should play an important role. Chemistry teachers should prepare themselves *now* to take an active part in training gas, fire, and air defense personnel, decontamination and gas detection squads. All teachers of chemistry should have the following handbooks put out by the U. S. Office of Civilian Defense: *Training Courses for Civilian Protection, First Aid and Treatment of Chemical Casualties, Gas Defense, Handbook for Decontamination Squads.* Another excellent handbook procurable from The British Library of Information in New York City, R. C. A. Bldg., is *Basic Training in Air Raid Precautions.*

There is a second important way in which the teacher of chemistry can help

increase the effectiveness of the home front. Our war effort is on such a tremendous scale that there is an actual shortage of many essential materials. For example, our average annual production of aluminum for the five years preceding 1939 was 256,000,000 pounds. Current production is at the rate of 700,000,000 pounds annually, and the supply is not equal to the demand. Hence, the absolute necessity to salvage every piece of scrap aluminum in the country to get it back into use. Aluminum is but one example of many materials of which there is an actual shortage. Recently the WPB published a report on the war status of many materials. In Group I are materials where the present supply is *not equal to the demand.* Citizens will have to do without consumer goods made of these materials or use available substitutes.

GROUP I.—"CRITICALLY ESSENTIAL FOR PROSECUTION OF WAR"

Metals

Alloy steels
  Iron alloys
  Wrought iron
Aluminum
Aluminum scrap
Cadmium
Calcium-silicon
Chromium
Cobalt
Copper
Copper scrap
Iridium
Lead
Magnesium
Nickel
Tin
Tin plate and tern plate
Tungsten
Tungsten high speed tools
Vanadium

Chemicals

Alcohol, methyl
Chlorinated hydrocarbon refrigerents
Chlorinated hydrocarbon solvents
Chlorine
Diphenylamine
Formaldehyde
  Paraformaldehyde
  Hexamethelenetetramine
  Synthetic resins therefrom
Phenols
Polyvinyl chloride
Sodium nitrate pure
Toluene

Miscellaneous

Agar
Asbestos—long fibre
Burlap and burlap products
Cashew nut shell oil
Corundum
Cotton linters
Graphite—Madagascar
Hempseed
Jewel bearings
Kapok
Manilla fiber and cordage
Pig and hog bristles
Rubber, crude and latex
  Chlorinated
  Synthetic
Shearlings
Silk
Silk waste
Silk noils
  Garnetted
Reclaimed silk fibre
Sperm oil
Tin cans
Titanium pigments
Tung oil

The chemistry teacher, through his teaching and professional contacts can help acquaint the general public with this shortage of many critically needed materials and emphasize that it is the patriotic duty of each one to do without consumer goods made from these materials, that they may be available for those of our nation who are at the front.

Again, the chemistry teacher can help to get his community "scrap and waste material minded." In every community there should be voluntary organizations to continually stress the necessity of saving scrap and waste materials to get them back into use. The steel industry which is at an all time "production high" is actually being handicapped because of the difficulty of getting sufficient steel scrap. Chemistry teachers do not need to be reminded that the charge of an open hearth furnace consists of steel scrap and iron as well as molten pig iron. Almost every freight train which we now see contains gondola cars filled with iron scrap bound for the steel mills. But there are not enough of them. A short journey through the country will reveal many carloads of scrap iron and steel, which not only detract from the beauty of the countryside, but which are rusting away. There should be an effective voluntary organization in each community to push the cause of—"Save your scrap to beat the Jap."

Because of their knowledge of the properties and uses of these vitally needed materials, teachers of chemistry are in a position to emphasize the necessity for saving all scrap and waste materials that can be reused. This includes:

1. All metal scrap, from an old baby carriage to a tooth paste tube.

2. All waste paper—newspapers, magazines and paper cartons.

3. All scrap rubber from an old casing to discarded garden hose.

4. All fats and edible greases from the kitchen.

We have become a prodigal nation. Of our annual production of paper in excess of 10,000,000 tons, only 22% went to uses where it was permanently taken out of use and only 28% was recovered. The remainder, or 50% was destroyed mostly by burning. Our grandmothers carefully saved all fat renderings from the kitchen for re-use, but now most housewives discard them or burn them with the garbage. If a million housewives in the State of Illinois alone would save a half pound of fat a week, it would be enough to produce 57,000 pounds of glycerol, not an inappreciable sum. Large hotels and restaurants have always saved their fats. We should do the same to help the family purse and to get added glycerine and fats for the war effort. The OCD has tried to set up machinery reaching into every community for this purpose, but whether or not the plant functions depends upon those who have the grease and fats to conserve.

I am sure that the large number of people who are not turning in scrap and waste material do not wish to be unpatriotic. Their apparent apathy is due to lack of knowledge. The OCD has an enormous task in setting up voluntary organizations in all communities to carry the message of civilian defense and the saving of scrap. The chemistry teacher should be functioning in this job.

The question may be asked, "How is the chemist to find his place?" In the first place, he should inform himself of the nature of the many tasks confronting the OCD; then he should volunteer his services in his own community. There is no reason why he should not assume a position of leadership in this work. Many chemistry teachers are doing that very thing. The writer for example, recently gave a demonstration lecture to 600 fire wardens on magnesium fire bombs with a discussion of the proper method of fighting them.

The chemistry teacher has another very important function to perform in this conflict. This is a war of machines, and men and women trained to operate those machines form largely a specialized personnel. Under the impact of war, college and university enrollments have decreased. No one knows how long this war will continue nor at what level college and university enrollments will again stabilize. In England and Canada enrollments have stabilized at about 50% of pre-war enrollments. No one knows if this will be true in this country. But our government and our military leaders appreciate the necessity of continuing the training of young men and women along lines necessary for the war effort. The newly announced V-1 program of the U. S. Navy provides for training up to 80,000 qualified young men with at least two years of college work. The newly announced plan for the U. S. Army Enlisted Reserve envisions a pool of college students large enough to supply 50,000 young people annually for the next four years for the officer training schools of the U. S. Army Air Corps. Those accepted for the army reserve will be allowed to finish their college courses. Then, too, women will have to be trained to fill many technical positions usually filled by men. In this vast training program, the chemistry teacher will play a very important part. He should encourage young men with aptitudes in mathematics, science, medicine, and engineering to get the viewpoint that it is patriotic to get as much training as possible. We can prepare for the war of two or three years hence *now*. While college enrollments will probably continue to decrease for some time, it is very probable that additional burdens will fall on mathematics and science departments. This may call for greater attention to duty and more working hours. In many cases this enhanced program will call for more effective use of physical plants. It certainly will call for a critical evaluation of course content in order to save time. All these chemistry teachers are ready to do to assist in training the increased quota of physicians, chemists, physicists, engineers, laboratory technicians, supervisors, and inspectors needed for war industries and the armed services. To paraphrase the words of a well-known news commentator at the close of each of his broadcasts—

"Chemists are proud to assume the responsibility of helping this nation to make an effective home front to make possible the successful conclusion of the war by those on the battle fronts."

Papers in Geography

From the Report of the Section Chairman

The Geography program carried 10 papers. Seven of these are herewith published, and, in addition, one from the previous meeting, submitted too late for publication in volume 34, namely that by H. O. Lathrop, but accepted by the Committee on Publications. Those given at the Urbana meeting but not published are as follows:

Brown, Clarence L., University of Chicago, Chicago, Illinois, *Regional reality from the concept of space-time.*

Fryxell, F. M., Augustana College, Rock Island, Illinois, *Burias, a little-known island of the Philippines.*

Wells, George R., Senior High School, Decatur, Illinois, *The relations of geographic factors to some diseases.*

Thirty attended the meeting and elected as chairman of the Jacksonville meeting May 7-8, 1943, L. A. Holmes, State Normal University, Normal, Illinois.

(Signed) Joseph Van Riper, *Chairman*

SAXICULTURAL DISTRICT OF THE SUDBURY AREA[1]

THOMAS F. BARTON

Southern Illinois State Normal University, Carbondale, Illinois

The most important cultural features of the Sudbury Area are those associated with the mining industry. Mines, smelters, and mining towns leave an indelible impression with the traveler. Tall smoke stacks with clouds of smoke and fumes; long freight trains of ore or glowing slag; huge blocky shaftheads near deep open pits; and large smelting and refining plants with their associated mining towns are dominant cultural scenes. Miners in their characteristic dress, increased traffic after the shift whistle blows, old dilapidated cars, unpainted unattractive houses on small lots along unpaved streets, these are the scenes which characterize this mining landscape and sets it distinctly apart from the others.

The mining industry does not occupy a large compact continuous area; rather, it consists of islands of concentrated development linked together by communication and transportation lines. This rough network of mining development is surrounded and enclosed on all sides by woods.[2]

The focal center of the mining development is Sudbury. Secondary railroads and highways connect the mining and smelting towns with Sudbury, the transportation and commercial "capital" of the area. Five miles west of Sudbury is Copper Cliff with its smelter and refinery. Eight miles east of Sudbury at Coniston is another smelter. Eleven miles to the northeast is the town and mine of Garson and four miles farther on is the mine and smelter at Falconbridge. Directly north is the Frood mine; and town; still farther north is the Stobie mine; northwest is the Levack mine and town and southwest is the Creighton mine and town.

Consequently, within a radius of twenty-two miles of Sudbury are found the six active mines, three active smelters and a refinery. These mines and smelters produce over four-fifths of the world's nickel, a large quantity of copper (Fig. 1). In addition to the six active mines, there are within this same area thirty-eight abandoned or inactive ones. (Fig. 2.)

This localization of mines is related to the ore bodies which outcrop in an oval shaped belt surrounding a structural basin. This is responsible for the pattern of active and non-producing mines. The only exception to the oval pattern are the mines located along mineralized dikes which appear as off shoots from the ore belt and the old lead-silver mine in the basin.

The greatest concentration of mines is in the south central part of the ore belt near Sudbury. Thirty-five mines are located here within an area thirty-six miles long and six miles wide. Two factors which aided in this mining concentration are: (1) this part of the area had the earliest and best transportation facilities and (2) smelters having been established in the southern part, it proved more efficient to use ores that were close at hand and needed only to be shipped a short distance.

Types of Mines.—Shaft and open pit are the two types found in the area. These may be further subdivided into classes according to their present development such as active, and non-producing. (Fig. 2.)

At the present time only six mines produce all of the nickel. Two of the shaft mines have associated open pits, while at the Stobie all ore is removed by the

[1] For practical purposes at present the writer uses the term "The Sudbury Area" when writing of that portion of Ontario included on the Sudbury Topographical Sheet which is published by the Department of Interior. The area is forty-eight miles long from east to west; thirty-four miles wide, and is named after its largest city Sudbury.

Information in this paper is based upon six weeks field work in the summer of 1939 and library research. The first article on the Sudbury Area, Ontario entitled "Agricultural Landscapes of the Sudbury Area, Ontario" appears in the Transactions of the Illinois Academy of Science, Volume 34, pp. 130-137.

[2] Refer to Figure 1 in article entitled "Agricultural Landscapes of the Sudbury Area, Ontario," Transaction of the Illinois Academy of Science, Volume 34, p. 131.

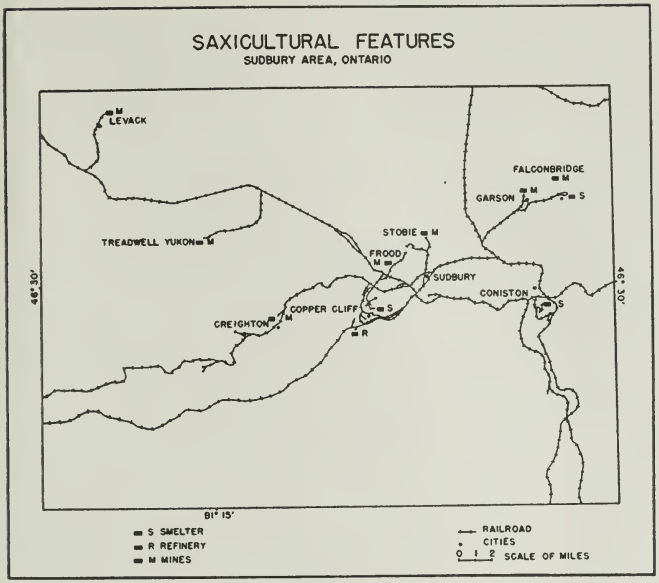

Fig. 1.

open pit method. The fact that thirty of the forty-three mines have open pits indicates that a high percentage went through the open pit stage.

The small number of active mines is not because of a paucity of ore or to the limited extent of the ore body. There are many mines that contain ore rich enough and pure enough to be mined but in peace time the world demand for nickel is limited. Consequently, only those mines are active where the ore is richest; where it can be most cheaply mined; where the least amount of undesirable impurities is found; where hauling costs to the smelter are low and where the desired ores for mixing may be obtained.

Stages of Development. — Six stages which may be recognized in the development of this mining industry are (Fig. 3).

1. Prospecting and Boom Period 1883-1905; during this period most of the mines were located and established.
2. Consolidation Period 1905-1920. This period was characterized by consolidation of small holdings until the International Nickel Company gained control of all the mines.
3. The Depression Period 1921-1922 followed the close of the First World War.
4. The peace time Production Period of 1923-1930.
5. The Depression Period of 1930-1933.
6. Second World War Boom Period which began in 1934 with an increased production of armaments throughout the world.

Vigor of the District.—When the entire mining district is considered, many factors indicate that the nickel industry will be permanent for at least the next fifty years. Some of the leading indications are (1) a steady increase in production, except for the short depression periods of 1921-1922 and 1930-1933; (2) the discovery and development of new mines; (3) a continued expansion of the railroad net; (4) a steady increase in the amount of hydro-electric power being used, and the enlargement of the power system, (5) the growth of such towns as Sudbury, Copper Cliff, Coniston, and others whose development is dependent upon the mining industry, and (6) the recent construction of larger and more substantial buildings as connected with the extraction of the ore and its treatment.

The vitality of the saxicultural district is expressed by the prosperous conditions of the cultural forms, such as new and well-constructed shaft-heads, processing plants, transmission lines and dams each of which has been built to last for decades to come.

The district has reserves of nickel ores larger than those found in any other

place in the world. In New Caledonia, the district's chief competitor, four hundred thousand tons of ore is considered to be a large reserve for a mine. In comparison it is estimated upon data obtained by diamond drilling that the Frood mine of the Sudbury district has a reserve of over one hundred and twenty million tons.

Present Development. — In 1939 the Sudbury Area produced 102,559 tons of nickel or approximately 83 per cent of the world's total. The second largest known nickel area is in New Caledonia with an estimated production of only 9,300 tons during the same year. Although the Sudbury mines are now being expanded, production of nickel in the Surbury Area is limited by smelter facilities. Formerly inactive, the Stobie, an open pit mine, began operation in 1939 in order to meet wartime demands. Although production facilities are now being increased, the production of nickel is insufficient to meet present demands.

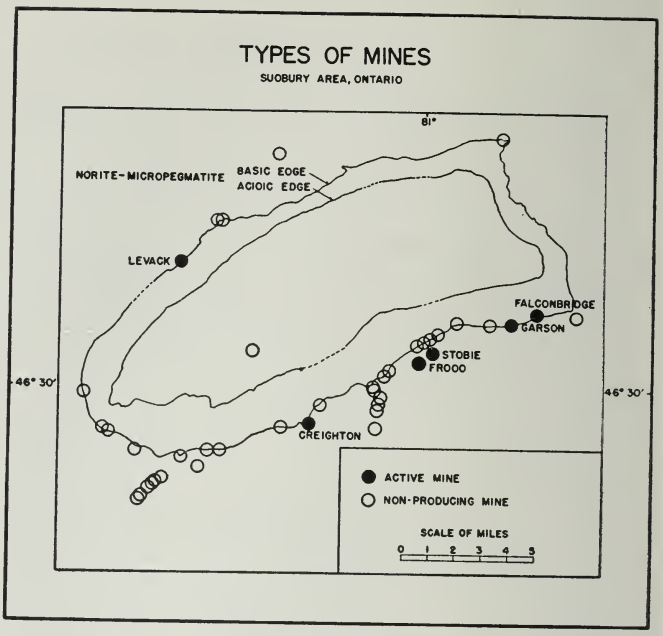

Fig. 2.

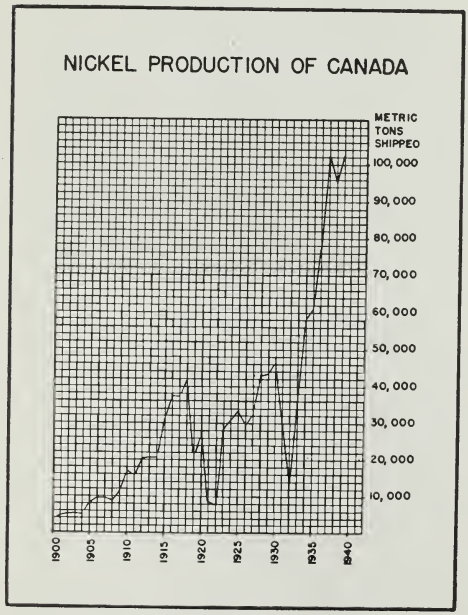

Fig. 3.

Summary.—The pulsating heart of the Sudbury Area is located in the active mines and in the plants connected with the treatment of ore. These give employment to the miners who occupy the towns and cities. The roads and railroads are built to connect the mines, smelters, cities and the agricultural areas which help feed them. Thus the quality and quantity of the ore together with the type and distributions of the ore body have been the dominating factors in producing the type and amount of cultural forms in the Sudbury Area.

THE BLACK SEA AND ITS BORDERLANDS

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Of the major coastal waters that fringe the Mediterranean Basin the Black Sea is perhaps the least well-known. For the most part this is due to the factor of location. It is too far off the main *through-water route* — Gibralter to Suez. Odessa is 1,000 miles north from this route. After all, the Black Sea is commercially a "blind alley". The ships that use it are mostly *tramp steamers* carrying out grain, oil, lumber and manganese, not the *trim passenger liners* usually associated with the "Mediterranean Cruises".

The Sea is really a sizeable sheet of water, a little smaller than the Caspian, about the same size as the Baltic, over 1½ times the area of all of our Great Lakes combined. Into it debouch several of the largest rivers of central and eastern Europe so that it is the catch-basin for about one-fourth of the whole continent. Since it is almost isolated from the ocean, tides have little effect and the rivers empty through vast swampy deltas. Many of the more important ports are, as a consequence, located either on the stream above the delta or on the coast some distance from the delta mouths. Rostov on the Don is an example of the first; Odessa, between the Dnestr and Dnepr, illustrates the second.

Some of the most interesting characteristics of the Basin are explained by its geologic history. Unlike the shallow North, Baltic and White Seas, formed by the gradual encroachment of ocean waters onto adjacent lowlands, the Black Sea, like the Mediterranean and Caspian, was formed by faulting and the foundering of large blocks of the earth's crust. Features likely to be found as a consequence of this type of origin are: (1) Great depths. Extensive areas of the Black Sea bottom are over 6,000 feet deep. (2) High coasts. In the Black Sea littoral only for two short stretches do extensive plains meet the water. These are at the Gulf of Odessa and the Sea of Azov. (3) Regular coast lines. The Black Sea has very few islands and good natural harbors are lacking. Breakwaters must be built and much of the loading and unloading of steamers is done by lighters.

Finally, an "accident" in geologic history seems to be responsible for the peculiar condition of the deeper waters. These lower levels of the Black Sea are charged with hydrogen sulphide and there is there an absence of the higher forms of organic life. During the Glacial Period much sea water was withdrawn to form the great ice sheets, the sea level was lowered and the Black Sea became an inland fresh water lake whose outlet was through what is now the Bosporus-Dardanelles gap. With the return of warmer temperatures, the ice melted and the sea level rose so that salt water poured from the ocean into the Black Sea. This destroyed the fresh water fauna which had developed there and although that was thousands of years ago the lower stagnant waters remain poisoned by the decompositions products and fish are absent. The surface waters, however, are well populated and in some parts of the coast, eg. the Danube delta, fishing is an important item of the domestic economy.

Climatically the Euxine, by which name the Black Sea was known to the Greeks, is in marked contrast with the Mediterranean. Entering by way of the Bosporus one feels that the name given by the Turks—"Black Sea" is very appropriate. You leave behind the blue waters, the clear air and bright skies for dark stormy waters, overcast heavens and dense fogs. Except along the southeast littoral, the borderlands receive rather light rain and their native vegetation is grass or steppe. Temperature ranges are greater than in the Mediterranean. The January isotherm of 32°F.—the same which passes through St. Louis—crosses a little to the south of the main Russian coast so that all of the rivers from the Danube to the Don, as well as the harbors, are ice bound part of the year. Odessa averages two or three weeks of ice; the Kerch Strait at the outlet of the Sea of Azov is closed for twice that

period. In this rather dark climatic setting there are two "bright" spots. In and about Batum, and on the southern tip of the Crimean peninsula, are outliers of the Mediterranean climate. Of the two the latter is far more interesting.

Jutting far out from the mainland the commanding position of Crimea has long made it a bone of contention among rival commercial powers. Indeed, to the average American, the peninsula is synonomous with the Crimean War, the "Charge of the Light Brigade" and the pioneering work of Florence Nightingale The incidents of the Peninsular War are now commemorated by a multitude of memorials and cemeteries near Sevastopol, the great Soviet naval base. However, Crimea has played a double role—that of a playground as well as a battleground. Russian travel literature refers to it as the "little paradise" and the "Russian Riviera". For most of the peninsula these titles are decidedly inappropriate. If one approaches from the mainland, for example, Crimea appears to be but a continuation of the dry, monotonous steppe of adjacent Russia. However, the Yaila Mountains an outliner of the Caucasus, parallel the southeastern coast and serve as a wind-break. Wedged in between these ranges and the sea is a climatic oasis—a land of mountains, sea, and flowers. To the north of these protecting ridges lies the windswept steppe, parched by drought in summer, and blanketed by cold and snow in winter. On the south, although in the latitude of Minneapolis, are found the mulberry, fig, olive and vine. Ice here is rare. The January mean is 20° warmer and the rainfall four to five inches greater than on the steppe. Little wonder that for cold Russia it should be regarded as a "paradise" and a popular resort for Czarish wealth and fashion. Today the royal residences, palaces and luxurious hotels have been transformed into rest houses for Russian workers.

The most interesting of the Black Sea features is the slender bottleneck outlet—the Dardanelles-Marmara-Bosporus waterway. The opening totals 52 miles in length and in form suggests a north-south winding corridor with a vestibule in the middle. It narrows to one-half mile in the Bosphorus; the coasts are rugged and there are numerous islands. A strong outward surface current flows to the Aegean, averaging about three miles per hour, but at times having twice that rate in the narrows. This is too swift to row against and in the days of sailing vessels, if combined with a strong north wind, ships might be held up in the Straits for a week at a time. A submarine current of heavy salty water flows toward the Black Sea. At Istanbul this return movement is at a depth of 60 feet and moves about four-fifths miles per hour. In configuration the Bosporus is a strait, in flow, a river and in depth, a sea.

Few important waterways are so easily defended for it allows control of all shipping by a nation without a *single* ship. Even the current can be used for floating mines among attacking vessels seeking to enter from the Aegean as was well-shown in the disastrous attempt of the British in World War I. Naturally this was a perfect stronghold for pirates and one of the world's strongest bands of sea raiders infested the Straits in the 16th century. The strategic and commercial significance of the Straits all through history is evidenced by the rows of ruins of cities and forts which line the shores on either side. Except for a brief period of internationalization, 1920-1936, Turkey has ruled the waterway for the past 500 years.

The Straits provide a water gateway for the Black Sea though in so doing they necessarily interrupt the land route from Europe to Asia. The intersection of these two provides a *situation* for a great commercial center. The drowning of a tributary of the Bosporus—the Golden Horn—provides the *local site*—a harbor protected from the currents of the main waterway. Given this magnificent setting, Constantinople for centuries during the Middle Ages was the world's leading city, but the blight of Turkish control has never allowed the full utilization of the opportunities offered even though few cities have equalled it in dramatic interest. In a recent typical year only five percent of the shipping through the Dardanelles was Turkish.

SOILS AND POPULATION—DECATUR COUNTY, GEORGIA

ALFRED W. BOOTH[1]

University of Illinois, Urbana, Illinois

In Decatur County most rural dwelling abandonment has resulted either from the eviction of share croppers where land owners are shifting from intensive to extensive agriculture in order to make more efficient use of soil, or from actual land abandonment where soil erosion and decreasing soil fertility have made such a step almost mandatory. To a certain extent the amount of house abandonment[2] may be considered to be an indication of the amount of change which has been necessary in order to reach an adjustment between the carrying capacity of soils[3] and farm population.

The amount of and reason for abandonment differs in each one of the five soils regions into which the Southwestern Georgia county has been divided.

Region I. This, the most homogenous of all the soils regions, is covered almost entirely by one soils type, the sterile Norfolk sand. The low productivity of Norfolk sand has long been recognized. Hence a fair compromise has long ago been effected between carrying capacity and population and the percentage of vacant houses is low (Table I). However, this last statement applies only to the two larger subdivisions, Ia and Ib. On subdivision Ic a land use system similar to the more favored adjoining Region V was imposed. This system has proved so successful that now one out of every nine dwellings has been abandoned.

Region II. In addition to Norfolk loamy sand, a soil somewhat better than Norfolk sand, this region contains large patches of Norfolk sandy loam and Tifton sandy loam, both of which are highly desirable coastal plains soils types. Population density as measured by occupied

TABLE I

	Total number dwellings	Total number vacant dwellings	Per cent total dwellings vacant	Occupied dwellings density (per sq. mi.)
Decatur County	5628	325	5.7	9.2
" " —Rural	2465	161	6.5	3.76
Soils Regions				
I. Norfolk Sand	1107	60	5.4	4.11
A	474	21	4.6	3.25
B	568	30	5.3	5.16
C	65	9	13.8	5.05
II. Norfolk Loamy Sand	215	16	7.4	4.45
A	106	7	6.6	4.81
B	40	3	7.5	3.59
C	73	6	8.2	4.86
III. Terrace Soils	130	23	17.7	1.27
IV. Escarpment Soils	53	6	11.3	1.22
V. Altamaha Upland Soils	960	56	5.8	4.81

[1] Field work made possible by a grant from the Graduate Research Board of the University of Illinois.

[2] Unoccupied dwellings from the Georgia State Highway Commission map of Decatur County, and field reconnaisance.

[3] Soils ratings established with the help of:

Hasty, A. H., et al. "Soil Survey of Decatur County, Georgia." *U.S.D.A. Bureau of Chemistry and Soils*, Soil Survey Series 1933, No. 24, 1939.

Mereness, E. H. "Farm Mortgage Loan Experiences in Southeastern Alabama." *Ala. Agr. Exp. Sta.*, Bull. 242.

Henderson, J. R. "The Soils of Florida." *U. of Fla. Ag. Exp. Sta.*, Bull. 334.

dwellings is greater here than in Region I, a direct result of the greater productivity of its soils. However, the percentage of abandonment is also greater here than in either Region I or the county as a whole. Most of this can be explained in terms of a shifting farm economy, although decreasing soil fertility is also a factor.

Region III. A number of soils series, the Kalmia, Cahaba, Leaf, and Flint, are represented on the terraces along the Flint River. Also included within this soil region are contiguous areas of Blan-

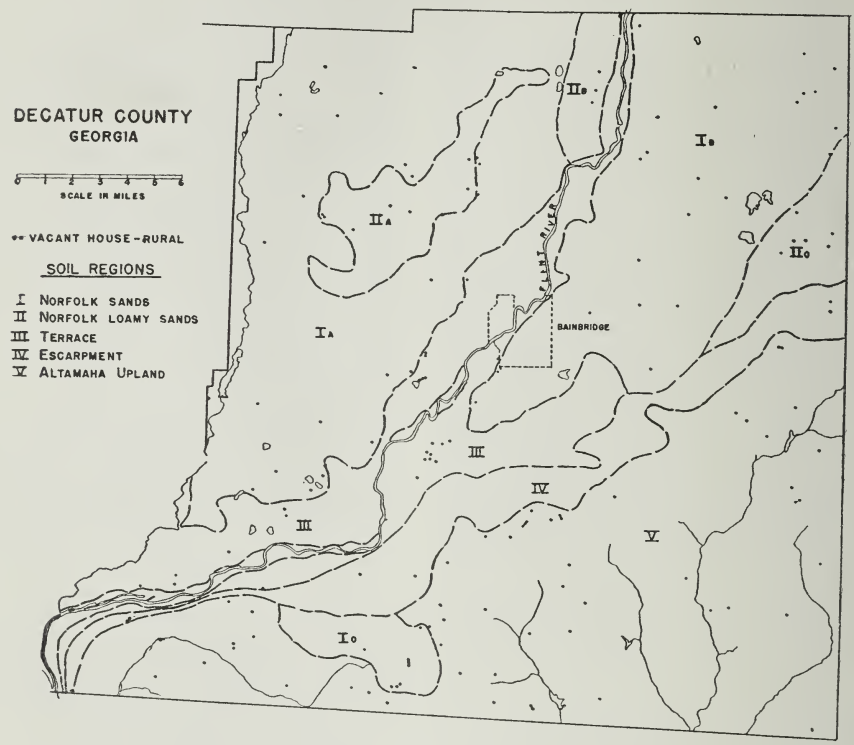

Fig. 1.

ton soils and the swamp lands of the first bottoms. Flint fine, sandy loam is by far the most extensive soils type. Most of the soils of the terrace have a profile in which sandy surface soils overlie a layer of sticky clay. Unsuited to cotton or peanut production, these soils have been taken out of cultivation very rapidly in the last decade. Locally they are called "cowhide lands" since they are excellent pasture soils. The percentage of abandoned dwellings in this region is higher than any other soils region in the county as a result of the shift from intensive cropping to extensive grazing which is taking place.

Region IV. Though largely in Guin soils, small areas of other soils abound. A broken and dissected area, it has never been extensively cultivated. Cleared lands are being eroded seriously as a result of sheet wash and gully formation. As might be expected, abandoned dwellings form a high percentage of the total dwellings in this region.

Region V. A great variety of soils types are represented here. Norfolk and Tifton soils are found on the flatter uplands, such red podzolic soils series as the Greenville, Magnolia, and Faceville on the upper slopes, soils of the Blanton, Cuthbert, Plummer, and Susquehanna on the lower slopes, and swamp soils in the river bottoms. The red podzolic soils are the premium soils of the region as well as the county, although such soils as Norfolk sandy loam and Tifton sandy loam do not rank far behind them. The

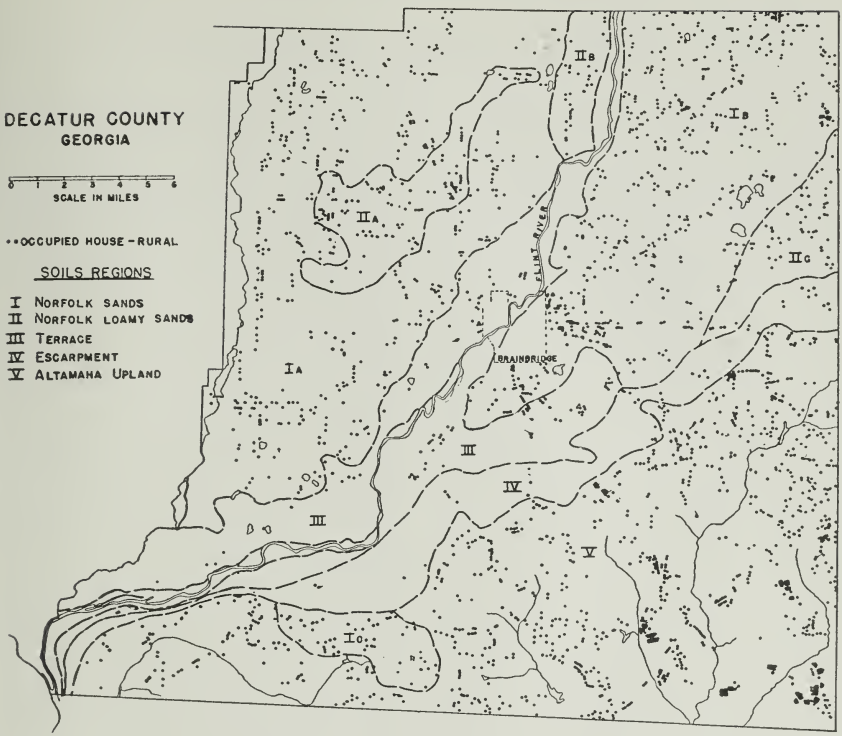

Fig. 2.

concentration of population on these upland soils can be noted in Figure 2. Intensive cultivation, particularly of shade-grown tobacco, has given this region a rather stable economy which its soils apparently are able to support. Many of the abandoned dwellings found here (Fig. 1) should be associated with the declining economy of the adjacent Norfolk sand area Ic and the Escarpment, rather than with the more or less stable economy of this region. Thus the actual amount of abandonment is negligible.

THE COLONIAL QUESTION

Flemin Cox

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The colonial question has been pushed into the background for the present, but it *was* a question of great significance at the close of the last war, and will again demand the most careful consideration of statesmen when the present war is over.

If the Axis powers should win, there would be no use to discuss the colonial question. We know that their desire is to reduce the whole world to slavery. We shall then discuss the question with the assumption that the United Nations will win. In the first place, some would question the right of any nation to have political dominion over other people and other lands. The principle of "Self-Determination" advocated in the speeches of Woodrow Wilson aroused desire and expectation among people of many lands, and living under various forms of political domination. Some are inclined to say let all the different peoples govern themselves. All liberal thinkers will agree that each people fit to govern themselves should be allowed to do so. Many will go farther and state that even "a second-rate government under native control is better than a first rate government under foreign control."[1] There still remain, however, many places in the world where even second-rate control may not be realized. Some islands and patches of land in other places are too small for responsible governments. Some people are too ignorant or too low in the scale of human development to govern themselves. If left to themselves, they might on the one hand, be subjected to cruel and inhuman treatment by native rulers, and in the second place they would probably impinge upon the more orderly portions of the world in such a way as to bring injury to the outside world. An example of such was the uncontrolled slave raids formerly made by Arabs of Northern Africa upon the negroes of the Sudan. Another, was the piracy practiced, for a time, by the Barbary States against the nations of Western Europe and even the United States. Another example is the exportation of opium by Iran. As the world communications become more closely knit, the spread of contagious diseases from low grade people, with no knowledge of sanitation, must be controlled. It is safe to conclude therefore that there still must be colonial government.

Germany and Italy have demanded colonies as outlets for their excess populations. In the first place, people from temperate lands do not wish to colonize tropical lands, but seek out new homes in independent countries in temperate lands. In the second place the rulers of Italy and Germany are not sincere, because they heap praise and even prizes upon mothers who bring forth large families.

From an economic standpoint colonies do not pay. Libya costs the poverty stricken people of Italy four times as much as is received from it. Other colonial powers show deficits also. Even if an annual expense and receipt account shows that the expense is not larger, the long time expense of conquest, development and control makes the colony an expense upon the people of the governing power.

Another reason for the desire for colonies is the prestige value. This of course is foolish and of no value and cannot be defended. It is, nevertheless, probably the most impelling reason behind the desire of Mussolini, Hitler, and of the Japanese. Against this foolish childish impulse we are today at war.

The statement that colonies almost always do not return to the governing country as much as they cost is almost universally true. This does not necessarily imply that no one may receive benefit from the colony. In fact, in almost every colony some favored individual may receive a liberal profit. Here again, the British may serve as an example. In spite of being a democratic country, the government is controlled very largely by the aristocratic class and the wealthy element. The younger sons of the aristocratic class need well paying jobs that are not beneath their dignity. Appointment to administrative positions

[1] Bowman, Isaiah—The New World, pp. 109-110.

with good salaries and other advantages often solves the problem of what to do with the younger sons. More important advantages may be secured by wealthy men and great corporations, who may receive valuable concessions to develop mineral deposits or other natural resources of the colony, at little cost to themselves, because of their preponderating influence with the government of the ruling power. In fact some members of the government may also be members of the corporation receiving the concession. In this case some few people may receive great profit at the expense not only of colony, but at the expense of the more numerous poorer people of their own country. This is one of the chief roots of imperialism, and statesmen of the future should see that special favor for privileged groups should have no place in the governments of free people.

The League of Nations, in spite of its faults and other weaknesses, advanced the idea upon which future colonial government must be based, if the idealism advanced as the program of the United Nations prevails. This is that the paramount purpose of colonial government is the welfare and well being of the colonial people. The Mandate System set up by the League of Nations, although administered imperfectly, called not only for government for the benefit of the people, but also called for an accounting, at stated intervals, by the governing country, to the League of Nations. These advanced ideas, should not be allowed to perish. They are the fruits of the highest development of the colonial system. This system, under the Romans, was little removed from slavery, in the early development of the colonial empires of Western Europe, the colony existed solely to be exploited by the governing country, and only slowly did the idea develop in the world that the welfare of the people of the colony should have first consideration. Kipling's "White Man's Burden" idea has long been considered a hypocritical excuse for British imperialism, but at long last, after Kipling's time has the new idea received the best consideration in the British colonies. After the British come the French who also have been working to a certain extent for the benefit of the natives.

One of the demands of the Axis powers, before the start of the present war, was for colonies. They made much of the "Have nots" and the "Haves" and while we now know, they were only using this as a plausible excuse for their desire to dominate other lands, they led many to believe that there was some justification for their demands. Let us examine the reasons put forward in the demands or desires for colonies. To understand these demands, the location of the colonial territories should be indicated. They are all in the hot belt of the world. The group of greatest importance from the standpoint of area and population are intertropical Africa, Second, the islands and peninsulas of southeastern Asia, Third, the West Indies and the Guianas, Fourth, the desert and semi-arid lands of northern Africa and western Asia. The development of the colonial system of today came from an economic impulse, from a world whose great powers were strong nationalistic states.

An important reason given for having colonies is the need for food and raw materials for industry, together with a market for manufactured articles. In order to help the metropolitan country, custom dues and other measures of preference must be established in its favor, both in buying and in selling. This has been done by some of the colonizing powers, least of all by the British who have been most successful. The curtailment of trade thus brought about by tariff preferment does not help, but hinders the well being of the colony. There has been in recent years a surplus, not a deficiency, in colonial products. There were products for all who had the money or the goods with which to buy. It does not require political dominion to do business with colonies. Furthermore the sources of most of the food and raw materials as well as the markets for manufactured goods are in independent countries. A reason behind the commercial one is the desire to control the products in time of war. Even this is not a valid reason because an enemy can cut off the colony from the metropolitan country and secure its products. Striking examples are the Netherland Indies which cannot supply rubber and quinine to the Netherlands, and Malaya which cannot supply Britain with rubber and tin. With a world organized on a basis of peace, this excuse for colonies is not valid.

THE MANUFACTURE OF CLAY PRODUCTS IN THE LOWER WABASH VALLEY

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The clay industry of the Lower Wabash Valley includes the manufacture of the various kinds of bricks, drain and building tile, sewer pipe, electrical conduits, pottery, sanitary ware, and a variety of other products. However, as far as statistical measurement is concerned, the manufacture of brick and tile far surpasses all other clay working industries.

Brick yards have always operated in the vicinity of the major cities and many of the medium sized and smaller towns of the United States, but there has been a tendency to concentrate at favorable production centers. By the end of the century, this trend began to manifest itself distinctly in the eastern states but was not noticeable in southern Illinois and Indiana until the World War era. Between 1910 and 1925 those plants which were unfavorably located with respect to raw materials, transportation facilities, and markets were gradually discontinued, leaving an area of four or five counties extending north and west from Brazil with most of the important clay plants of the region. Within the last decade about one-half the remaining plants have closed and Clay County (Indiana) remains as the only important producer of clay products within the area.

An Early Period of Small Plants.—The clay industry of the Valley dates from about the middle of the last century,[1] but it was about 1900 before a large clay plant was built in the Wabash Valley.[2] Although brick making was almost as widely distributed as town-building, most of the plants were small and, in general, served only the immediate vicinity. (In 1880 there were thirteen brick and tile plants in Vigo County and six in Knox County.[3] After 1900 the introduction of more modern brick-making machinery and the growing demand for specialized products (pressed brick, fire brick, and paving brick) encouraged a greater degree of specialization, which has continued from that time to the present decade. By the end of the century Terre Haute had only six plants, three in 1930, and only one by 1940.

Although a number of large plants followed in rapid succession after 1900, the trend away from small establishments was not yet apparent in 1913. The Clay Products Directory[4] for that year lists more than 75 plants located in 44 cities and villages of the area. Every county except Wabash, Gibson, and Pike was represented, and Clay County continued its early leadership with 15 concerns, some of which made several different ceramic products.

Industrial Selection Within the Last Decade.—The unusual demand for drain tile in the Corn Belt of Illinois and Indiana gave special impetus to that phase of the industry. This region was within the area of Wisconsin glaciation and the postglacial epoch has been so short, geologically speaking, that the drainage of large areas had not become organized by the time of white settlement. This, in part, accounted for the development of the National Drain Tile Company of Terre Haute which was rated as the "strongest tile plant" in the state in 1931. It marketed about two-thirds of its products within Indiana and 80 per cent

[1] One of the oldest ceramic plants in the state is the Griffith Pottery at Clay City which was established in 1848 and has been operated continuously since that date. (G. I. Whitlatch, "The Clay Resources of Indiana," Indiana Department of Conservation, Division of Geology, Publication No. 123, 1933, p. 107). The first tile made in Indiana was made by a handpower machine in 1852. (W. LeRoy Perkins, "The Significance of Drain Tile in Indiana," *Economic Geography*, Vol. 7, 1931, p. 382.)

[2] Brazil was an early leader in this industry and the first large plant in that area was built in 1891. (The Terre Haute Tribune, Vol. 91, No. 62, Jan. 31, 1940, Sec. G. p. 15.)

[3] Tenth Census of the U. S., 1880, Manufactures.

[4] Directory of Clay Products Manufacturers in the U. S., compiled by L. L. Longdon, 1913.

of the rest in Illinois, but the remaining sales were scattered over nine states.[5]

This industry has suffered severely in recent years. The business depression affected the farmer in numerous ways and thereby limited the sale of drain tile. When he experienced a recovery the purchase of new machinery and the upkeep of the farm buildings and fences, rather than further draining of the fields, have occupied his time and taken what money could be spared for improvements. The United States land policy of adding acreage in the irrigated west and retiring from production a similar acreage in the eastern states has tended to retard the further reclamation of wet lands. The conservation program has limited the acreage of soil depleting crops which, in general, are the crops that require well drained soils. As a result, the drain tile plants have ceased operations or, at most, are working only a day or two per week.

According to the 1930 census Illinois and Indiana ranked second and third in the manufacture of brick and tile, making about 18 per cent of the national total,[6] however, the number of establishments has decreased consistently since 1900.

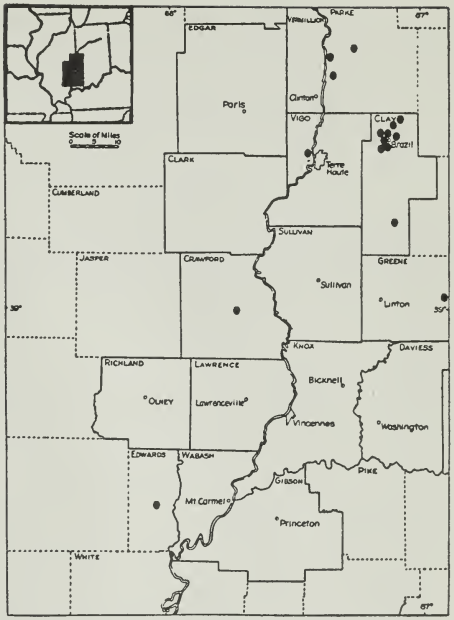

Fig. 1.—Although brick and tile plants were located in nearly every county of the area, most of the major clay products plants that remain in operation are localized in the Brazil (Indiana) district.

The clay plants in the Illinois portion of the Valley had decreased from 27 in 1913 to four in 1929, and three of those have since been closed. The only addition was the W. A. Case Company, a large concern manufacturing sanitary ware, which located in Robinson shortly after 1920. In Indiana the proximity of cheap fuel and a more suitable supply of raw clay were responsible for the survival of a greater percentage of the original plants. Whitlatch[7] shows 37 plants in the area, 13 of which were in Clay County, and 14 of the remainder in Vermillion, Parke, and Vigo Counties. The recent depression has reduced this number by more than 50 per cent. In 1940 only ten firms were operating in Clay County, three in Parke, and one each in Vigo and Vermillion Counties. (Fig. 1.) Within the last two years two plants (at Newport and Brazil) have discontinued operations. It is true that economic conditions have contributed greatly to the decline of the industry, but the shift to other construction materials has also been a vital cause. Concrete and asphalt preparations have replaced the use of brick in road construction and the first named has become an important material in the building of city structures. It is easier and cheaper to pour a building than to construct it of brick.

Most major brick-making centers are located in the vicinity of the large cities, but the Brazil region has been able to develop a clay industry and remain an important producer despite the absence of nearby urban agglomerations. A number of factors have contributed to this success: (1) The operators have had easy access to an ample supply of raw materials. Most of the plants use underclays or shales associated with the local coal measures and in many cases their pits are located within a few hundred feet of the plant. (2) The proximity and cheapness of the fuel as well as the clay is another vital factor, and not infrequently these two major raw materials have their source in a common mine or pit. (3) The area possesses an efficient transportation system, all major plants having switching facilities from one of

[5] Perkins, *op. cit.*, p. 380.
[6] Fifteenth Census of the United States, 1929, Manufacturers.
[7] Whitlatch, *op. cit.*, p. 68.

TABLE I.—BRICK AND TILE PLANTS OF ILLINOIS AND INDIANA[1]

Date	Number of establishments	Value of products	Value added by manufacture
		Thousands	
Illinois			
1899	566	$ 5,081	$ 4,055
1909	340	9,765	7,274
1919	144	17,564	12,734
1929	101	23,685	17,782
1939	48	5,861	4,313
Indiana			
1899	558	$ 2,931	$ 2,379
1909	311	4,719	3,413
1919	151	9,881	6,444
1929	77	15,948	11,841
1939	27	3,143	2,288

[1] Data from the United States Census Reports.

the principal railways. At present the rail connections are of less importance than in the past, because the bulk of the clay products now moves on the highways. A decade ago Perkins[8] noted that most of the drain tile transported within Indiana and a large part of that sent to points outside the state was carried by motor truck. (4) Skilled labor is essential for only a few positions, and the rise of the brick industry coincided with the decline of Terre Haute iron and steel production, so an adequate labor supply has always been available. (5) Efficient business connections and organizations have placed the industry on a firm basis, and some plants are units of major organizations with headquarters in St. Louis or Cleveland. (6) Some plants have developed sidelines or secondary products, and (7) during normal periods, adequate and usually vigorous markets have been available.

The products have their greatest market in Indiana or the adjacent portion of Illinois, but a limited quantity is transported to more distant parts of the country. In general, the brick and drain tile are sold principally in Indiana and the adjacent states, while the more specialized products supply a market that extends over a wider area. The National Drain Tile Company (no longer operating) sold its product in eleven states.[9] The two plants of the Brazil Clay Company, manufacturing face brick, serve a market extending over a radius of about 500 miles. Hollow building tile and silo blocks have been shipped to points in a half dozen nearby states. The principal market for sewer pipe is Indiana, Illinois, Wisconsin, Missouri, and Oklahoma. Fire brick and special shapes are sold in the Chicago market and fireplace bricks have an extensive sale in the southern states. The Clay Products Company, which once owned three plants near Brazil, was unique in that all of its output was shipped to points outside the state. However, the one remaining plant was recently taken over by the Arketex Corporation which now operates two plants. A decade ago floor tile was distributed throughout the United States with selling points at Chicago, New York, and Californian and Canadian cities, and the sanitary ware of Robinson has a national market, the home offices of the Case Company being located in Buffalo.[10]

[8] Perkins, *op. cit.*, p. 380.
[9] *Ibid.*
[10] Whitlatch, *op. cit., passim*, and personal interviews by the writer.

THE USES AND PRODUCTION OF TUNG OIL

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Tung oil has been known and used in China for over sixty centuries for shipcaulking and as an ingredient in Chinese lacquers, but it was not introduced into the United States until 1869.[1] Its use was quite limited until during the World War when its values were first recognized. Since then its versatility has brought it recognition as a valuable and useful natural product.

Tung oil is the fastest drying oil known. A drying oil is one that makes substances with which it is mixed nonabsorbent, completely repellent to water. Thus the addition of tung oil to certain organic and inorganic compounds and rosins gives quick-drying power to varnish and the ability to absorb oxygen and form a hard protective film that is resistant to boiling water, freezing, and former whitening effects.[2]

The general availability of tung oil in quantities commensurate with our growing needs served to heighten its value in spite of certain drawbacks, and in the opinion of a leading chemist its production has completely revolutionized paint and varnish manufacture.[3] By 1939 American manufacturers were relying upon it as their major drying oil.

Despite the earlier use of tung for lacquer, it was not used in paints in this country until 1936. In that year a new kind of paint, whose basal mixture consisted of 45% soy and 55% tung oil, was introduced. Thus in discovering a new use for soy oil the paint industry also broadened the use of tung oil. The addition of soy oil keeps tung from solidfying at a relatively low temperature and prevents destructive distillation that occurs when it is used alone.[4]

The modern auto is most grateful to tung. Cheaper but better paint and filler jobs, improved gaskets, high grade brake linings, enameled surfaces, shellac, and bakelite and plastic fittings often depend upon it. Linoleum and oilcloth makers likewise tip their hats to it, while numerous other things, some of them vital to defense, have been improved with its addition. Raincoats, shower curtains, and balloon coverings now shed water because of tung treatment, and shot cartridges withstand wetting to a greater degree than before. Even a rubber substitute has been developed which is composed basically of tung.

Timber-poor China has long employed whatever means possible to prolong the life of paper and wood. It is tung oil that the Chinese have used to water-proof their buildings and writing materials,[5] to line their junks, as an important constituent in their varnishes, lacquers, paints, and japanning processes, and to give permanence to their masonry.[6]

Certainly the extensive use of tung has been a bonanza to American, European, and Chinese manufacturers and has improved the appearance of office, home, and barn.

Whereas tung is indigenous to various parts of Malaysia, Africa, and certain Pacific islands, China has long been the chief producer and exporter. In commercial circles and in parlance common to those acquainted with the oil it has been called chinawood oil. This is a misnomer. It is not a product of the wood, but is the oil extracted or expressed from the fruit of the tung tree. The word *TUNG* is Chinese for *heart*, and the leaf of the most important species of the family to which tung belongs is heart-shaped; hence the name. The tree is brittle and is usually covered with a maze of beautiful bell-shaped, generally

[1] Phillips, M. O.: Florida's Infant Industry, *Economic Geography*, vol. V., October, 1929, pp. 348-357.
[2] Pulsifer, L. Valentine: The Romance of Valspar, Valentine & Co.
[3] Gardner, H. A., and Butler, Paul H.: Tung Oil Culture, National Paint, Varnish, and Lacquer Association, Inc., Washington, June, 1937, p. 8.
[4] Anonymous: Tung Oil's Marriage to Soybean, *Review of Reviews*, vol. XCIV, September, 1936, p. 4.
[5] Phillips: *Op. Cit.*, p. 348.
[6] Gardner and Butler: *Op. Cit.*, p. 2.

pink or white, entomophilous blossoms, which precede the leaves.

Inasmuch as tung is sensitive to cold weather, it thrives only in tropical and subtropical regions. In China, *Aleurites fordii*, the chief species, is important in four provinces, Szechwan, Hunan, Hupeh, and Chekiang, while *montana* species does best in tropical Kwangsi province, west of Canton.

It seems that the first seeds to produce tung trees in America were imported from China in 1905. In that year the United States Department of Agriculture received nuts from Consul-General Wilcox of Hankow. The Experiment Station at Chico, California, presumably planted them at once.[7] Concurrently Dr. David Fairchild, in charge of the Division of Plant Introduction of the United States Department of Agriculture, became actively interested and through his efforts plantings were made in Alabama, Florida, Georgia, Louisiana, Mississippi, South Carolina, and Texas.[8] By 1909 a government contingent was optimistically investigating tung conditions in China.

To the enthusiasm and experimental work of the late William H. Raynes, a well-known horticulturist of Tallahassee, Florida, is due much of the credit for the early developments of the tung oil trees in Florida, and that state leads in the promotion and interests of tung growth in the United States. From Raynes' one successful tree the first grove of commercial importance in the United States originated.[9]

With the favorable reports of the government "spies" who had investigated the growth of tung in China, expansion in the South appeared to far-sighted individuals a just and profitable venture. Both the Bureau of Chemistry and Soils and the Bureau of Plant Industry have assisted in the expansion of tung groves and production through many experiments, while state and local agencies have been devoting much attention to the production of tung crops as an economic policy.

The first extraction of American oil that was sufficient to attract commercial interests took place in January, 1929. As the extracting machine was installed near Gainesville, Florida, and the golden oil was pressed out, nationally known manufacturers, representatives of internationally powerful financiers, chemists, agriculturists, scientific workers, and many curious and interested laymen looked on. Since then extracting mills have been established at numerous places in the Tung Belt. The Belt extends along the Gulf from eastern Texas to central Florida, a strip of territory generally not exceeding 100 to 125 miles in width.[10]

Thus far tung production in the United States has been negligible compared to the huge amounts China has contributed. Our 11,000,000 pounds produced prior to 1941 were about 1.5% of the amount imported during those years. Yet the decade of the thirties showed a remarkable increase from practically nothing to 4,000,000 pounds produced in 1940. In 1939 there were over 12,500,000 trees in the United States, one-third of them bearing. This number is constantly increasing.[11]

Imports into the United States increased steadily from 1914 to 1937, amounting in that year to 175,000,000 pounds,[12] valued at $25,000,000 (U. S.). But since then the Chinese Incident has greatly curtailed Chinese exports which have finally been entirely cut off. Meanwhile, American production is far from sufficient to supply recent demands. But on the optimistic side there are three noteworthy facts: that American oil is of much higher quality than Chinese and hence goes farther; that the mixture of tung oil with certain other lesser-quality oils now produces very excellent drying results; and, that our production is increasing.

Therefore, it appears logical that the United States will continue its efforts at becoming self-sufficient whether China rises again as a great exporter or not.

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[7] Newell, Wilmon, et al.: The Tung Oil Tree. University of Florida Experiment Station, Gainesville; Bull. no. 280, June, 1935, p. 26.

[8] Concannon, C. C.: Tung Oil Blue Book, USDC Bureau of Foreign and Domestic Commerce, Washington, 1938, p. 3.

[9] Gardner, H. A., and Butler, Paul H.: *Op. Cit.*, p. 30.

[10] Concannon, C. C.: *Op. Cit.*, p. 5.

[11] Dickey, R. D.: Personal communication.

[12] Inspectorate General of Customs (China): Foreign Trade of China, Maritime Customs (export volumes only), volumes covering years 1913 to 1939 inclusive.

After cessation of the war China will have to try to undersell the United States and must produce better oil if she's to compete with us. Tung has definitely had a setback because of the war, but it may emerge in a healthier, cheaper, and more stable condition if and when our South provides our needs, which according to some tung authorities may be as early as 1947.[13]

[13] Anonymous: H. W. Bennett on Expansion of the Tung Industry, *New York Times*, June 26, 1932, part LV, p. 10: 2.

THE MURNGIN: AN EXAMPLE OF HUMAN GEOGRAPHY

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Abstract

The Murngin are only one of several small and scattered nomadic hunting and food gathering tribes of Australia. They wander over the low alkaline plain of northeast Arnhem Land, located between the Gulf of Carpentaria and the Timor Sea. This tropical location, which brings the region under the influence of the alternating rainy doldrums and dry trades, limits the number of people who may inhabit the land, and sets limits to the activities of the inhabitants. Fortified by mangrove jungle isolation along the better watered portions of the flat coastal region and tidal rivers the tribe has long been preserved from invasion in that direction. On the south the burning sands of the Great Australian Desert closed the door to destructive inroads on their civilization. Thus in this remote refuge the geographical factor of isolation made it possible for these primitive people to live happily within the resources of the region, and to preserve intact the customs and beliefs which were common to the whole human race in its infancy.

Influence of Water.—Tribal life is focused around one or more water holes which may be an ordinary small lake or pool, a river or a creek flowing through the domain of the clan, a spring, a native well or water hole; and in a few cases it may be the ocean itself.[1] Small wonder that with food and drink of life dependent on the water holes, and possible death resulting from floods, the native has chosen water as the chief symbol of the clan's spiritual life.

The seasonal fluctuation of plenty or scarcity of rainfall regulates the membership and size of the economic groups. In the early part of the dry season when food is plentiful friendly clans may live together in groups containing as many as thirty or forty people. But what might have been a community relapses into family groups as the drought drags on for five or six months. Likewise in the rainy months when food is secured with difficulty, the group is small.

Vegetation and Animals.—The plants that flourish in this tropical region with alternating wet and dry seasons are limited in variety. Cycad palm nuts, Pandanus fruit, the glutinous substance from the trunks of small cabbage palms, spear grass, lily roots and yams make up the chief vegetable diet of the people. Every kind of tree found in the environment is used for some purpose.

Hunters they were and hunters they have remained. Roaming of course, is necessary, since the natives cannot depend on a regular food supply. The lack of domesticated animals cannot be fairly charged against the Murngin. With nothing higher than a marsupial to work with the scope was limited. One could hardly expect them to accomplish much with a kangaroo or a duck-billed platypus. Nature is prodigal as regards varieties of fish, birds and other animals which furnish the natives with food and material for adornment. Oysters and other varieties of bivalves are gathered by the women; and turtles, sharks and crocodiles are harpooned by the men. Snakes, iguana and grubs are also common articles of food.

[1] Warner, W. L., A Black Civilization, p. 20.

Soil and Mineral Influences.—Except as the soil affects the natural vegetation and the vegetation in turn determines the food supply, it can be said that soils influence the people very little.

Rocks and minerals, on the other hand, play a significant part in the culture of the Murngin. Every native knows for what this or that stone is used. Smooth river stones are gathered for ax heads, and small stones are used to break mussel shells and to grind nuts or seeds. "Rock ledges forming caves are sometimes utilized as shelter during the rainy season. Rock basins which catch rain water are used as types of primitive cisterns to supply water in the absence of wells and fresh-water courses."[2]

Deposits of red and yellow ochre are used in making body paints, in painting totemic emblems, and in working out designs on carrying baskets, forehead bands, etc.

Shelter.—People who must adjust their lives to a shifting food supply must construct a shelter that can readily be built with each new change of location. Furthermore, the dwellings must have a periodical alternation of type due to marked seasonal change of wind and precipitation.

During a good part of the dry season, the only shelter is some tree underneath which a semi-circle of ground has been smoothed and outlined by a border of sand and perhaps a series of strips of paper bark. Another type of dry season shelter is a lean-to or windbreak three or four feet high, made by placing brush against sticks pushed into the ground.

The wet season house calls for an adjustment to fifty to sixty inches of rain during a three or four month period. It is a small, dome-shaped house made by placing layers of bark over a framework of sticks and pandanus leaves. The stone cave dwelling is used by some clans in the north during the wet season. It is interesting to note that clans living near mosquito infested swamps build their houses on poles about eight feet above the ground.

Clothing.—For the Murngin there are no changing fashions. If one excepts the carrying bags, hair belts, necklaces, and public-aprons made of opossum fur string as articles of ornamentation or for ritual purposes, it may be said that the Murngin have neither invented clothing nor borrowed it from others.

Weapons and Utensils.—Stones, shells, wood, bark, resin, grass, leaves, and bones of animals—all of these are formed into weapons and utensils by which the native adapts himself to his natural environment. While the use of the bow and arrow does not seem to have occurred to him, the spear and ax are in general use. Clubs and boomerangs used for striking blows are commonly made of ironwood or the curved roots of the mangrove. Roots, yams, grubs and small lizards are dug with a digging stick made by sharpening both ends of an ironwood stick about four or five feet long.

String, basic to most of the articles worn and carried, is made of the inner bark of certain trees (the hibiscus in particular), roots of trees, human hair and opossum fur. Fiber bags woven to transport lily bulbs, cycad nuts, yams, and other foods are important utensils of both the men and the women.

Tools for catching sea food include turtle harpoons, harpoon rope, fish nets and fish traps. People in the interior do not possess boats of any description but use a specially constructed bark bundle as a raft to cross streams. Coastal people, on the other hand, make canoes from certain types of fig and eucalyptus trees whose centers have been eaten out by termites.

Art.—The art of the Murngin is conditioned by the natural environment, the most familiar objects occurring with greatest frequency. As one might expect, figures representing animals such as the snake, kangaroo, and fish bulk large in the art motifs of their crude rock drawings and eucalyptus bark paintings. Art also finds expression in the human hair belts decorated with parrot feathers, spear grass armlets, wristlets and anklets, totemic emblems of various kinds, feather headdresses, and forehead bands for men made of fiber string covered with white clay or red ochre.

Myths and Rituals.—Many of the myths and rituals symbolize the cycle of rainy and dry seasons with the accompanying phenomena of greater and less heat, changing winds and sky conditions, growth and decay of vegetation, and the

[2] Warner, W. L., A Black Civilization, p. 152.

appearance of certain animals and the disappearance of others. This is not surprising when one considers the need of change in the adaptation of Murngin life to fit the changing seasons.

Rhythmic dance movements interpret the rise and fall of flood waters, the flow and ebb of the tide, the wash of the waves covering the sand beaches, the stir of water when the waves break, and others equally meaningful.

Although the natives do have a profound belief in magic, they have a fairly wide knowledge of both plant and animal remedies for curing illnesses. Infusion of broken-up leaves of paper-bark tree is the remedy for sore throat; the bark of the plum tree is heated and placed over the aching tooth or against the aching ear; infusions of the leaves of certain trees are used to treat headache; and the inner bark of a certain variety of eucalyptus tree is chewed and swallowed to relieve chest cold.[3]

Thus we have glimpsed the life of a simple people, a self-contained, a self-sustaining people; a people whose culture is crystallized by the geographical factor of isolation, and whose needs and tastes are satisfied by a physical environment which is both limiting and stimulating. It is to be hoped that the Australian government, which has already reserved Arnhem Land for its natives, will give adequate patrol to this fast dying race, remnants worthy of sympathetic effort to save as a unique link with the past.

[3] Warner, W. L., A Black Civilization, p. 221.

THE DROUGHT OF CENTRAL UNITED STATES, SUMMER AND AUTUMN, 1940

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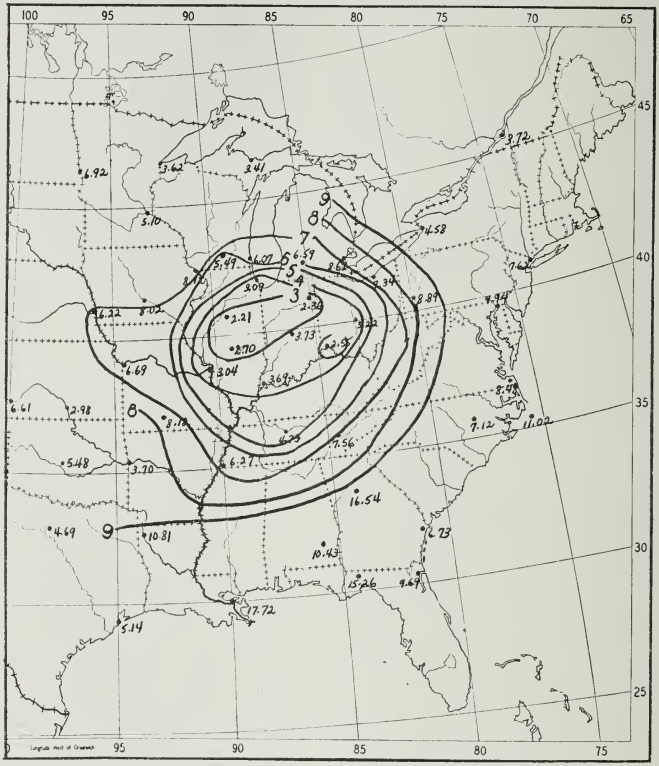

Fig. 1.—Rainfall in inches, July and August, 1940.

Droughts in the United States may be divided into two general classes. One of these is a transitory type affecting a relatively small area. The other type is the one which affects large areas over a number of years, in some cases a decade. Such a prolonged drought occurred in the United States during the decade 1930-1940, and another of the same type occurred in the later eighties and early nineties of the last century. The years 1934 and 1936 were the most serious drought years of the dry decade of 1930-1940.

Although the drought of the Central United States for the summer and autumn of 1940 came at the end of a decade of low precipitation, it belongs to the transitory type of drought because it affected a comparatively small area, and heavier rainfall prevailed on all sides. However, in much of the area affected the precipitation was far below normal, and in some places lower than during the more serious general droughts of 1934 and 1936. The 1940 drought of central Illinois was actually one of 19 months duration extending from September, 1939, to April, 1941, and in some parts of the state it was not broken until the autumn of 1941. The average precipitation of central Illinois during this period was only 70% of normal. The deficiency of precipitation at Peoria during this 19 months was five

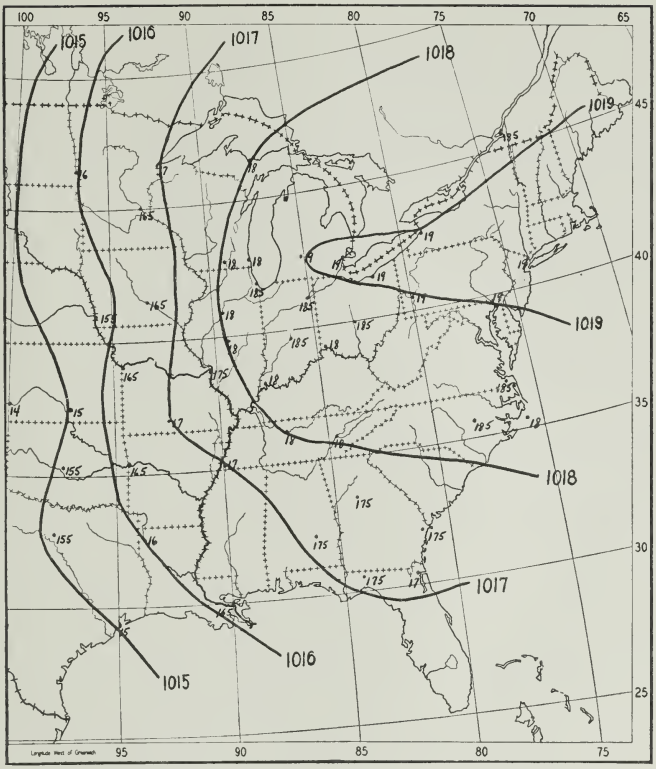

Fig. 2.—Average pressure, July and August, 1940.

per cent below that of any previous drought, thus setting a record for low precipitation for that station.

The normal rainfall for Peoria for July is 3.58 inches, but July 1940, had only .82 of an inch. The normal rainfall for the same station for July and August is 6.70 inches, but the 1940 rainfall for these months was only 2.21 inches or less than one-third of normal. Peoria may be taken as a type station since it lies near the center of the drought area.

It will be noted that the heart of the drought area is elliptical with the long axis running from northern Missouri through central Illinois, northern Indiana, and into northwestern Ohio, (Fig. 1). Perhaps the most striking fact emphasized by the isohyetal map is the increased precipitation which prevailed in all directions from the drought center, even toward the generally dryer west. The increase of rainfall outward from the center was rapid; so that within 100 miles in some directions the amount of rainfall trebled, and in some cases there was actually too much precipitation for optimum crop conditions. The region lying to the north of the drought area, including northern Illinois, Wisconsin, Michigan, and parts of Iowa, had exceptionally heavy rainfall.

The explanation of this small but severe drought over a limited area appears to lie in the high pressure which persisted during the severe drought months of July and August, 1940 over much of eastern and southeastern United States. (Fig. 2). Undoubtedly it represents a westward extension of the Azores High Pressure Area over southeastern North America. The high pressure prevailing over that portion of the United States prevented rain bearing winds from coming into the central part of the country from the Gulf and South Atlantic. At the same time, cyclonic areas moved around the area of high pressure far north over the Lakes Region, thus leaving the drought area unaffected and without rain.

Papers in Geology

From the Report of the Section Chairman

Seventeen papers were included in the Geology section of which 8 are herewith published. Those not published were as follows:

Gutschick, R. C., University of Illinois, Urbana.—*Redwall limestone of north-central Arizona.*

Schopf, J. M., Illinois State Geological Survey, Urbana.—*The morphology and distribution of Tasmanites ("Sporangites"); problematic fossils of the Devonian-Mississipian.*

Lowenstam, H. A., Illinois State Museum, Springfield, Illinois.—*Niagaran cherts from northern Illinois and southeastern Indiana.*

Simpson, Edwin, University of Illinois, Urbana.—*The Pleistocene geology of Garrison quadrangle, North Dakota.*

Brokaw, A. L., Illinois State Geological Survey, Urbana. — *Small spores from Illinois No. 5 coal.*

Easton, W. H., Illinois State Geological Survey, Urbana. — *Incompetent sediments in the Illinois basin.*

Rowland, R. A., Illinois State Geological Survey, Urbana. — *Thermal analysis of pyritic clays.*

Grogan, R. M., Illinois State Geological Survey, Urbana.—*Shape variation of some Lake Superior beach pebbles.*

Agnew, Allen F., University of Illinois, Urbana.—*Devonian stromatoporoids.*

Sixty-five attended the session.

Chairman for the Jacksonville meeting is W. E. Powers, Dept. of Geology, Northwestern University, Evanston, Illinois.

(Signed) A. H. Sutton, *Chairman*

THE "TRENTON" NEAR MORRIS, ILLINOIS

C. L. Bieber

North Central College, Naperville, Illinois

Eight miles north of Morris, Illinois, in the north limits of the village of Central, SW. ¼ Sec. 28, T. 35 N., R. 7 E., a quarry exposes rock of Trenton age. Culver[1] has briefly described this location in his report on the Morris Quadrangle. The Galena rock in the quarry is of particular interest because it is one of the few places in northeastern Illinois where relationship between the Kimmswick of Missouri and the Galena of Wisconsin and Illinois may be studied. The quarry is located on a gentle rise on a rather flat till plain. Three to five feet of till covers the rock, the upper surface of which has been polished and striated by glacial action. The striae strike S. 55° W.

Apparently this area of Trenton rock represents an erosion remnant which has been planed off by glacial action. However, the fact that the Maquoketa contact is five and one-half miles east, and Pennsylvanian rocks overlap beds of Trenton age one and one-half miles south and west indicates the possibility that the quarry is on a minor fold extending from the LaSalle anticline. Payne[2] has studied the subsurface conditions west of Central and found evidence of faulting near Sandwich and Millbrook, Illinois. His studies disclose a number of minor structures associated with the LaSalle anticline, and one of these may be represented near Central.

Mottling.—The middle and lower beds of the quarry have a peculiar and striking mottled appearance. The main mass of the rock is light gray, but the mottles stand out as darker grays and browns. The mottling is not a surface staining; darker areas penetrate the rock in an irregular pattern.

The quarry walls in the mottled horizons were tested in many places with a 50% concentrated solution of hydrochloric acid. The light colored portions of the rock effervesce as a relatively pure limestone, while the stained areas react more slowly. Samples of the light and dark colored rock show the following analysis:

	% light	*% dark*
SiO_2	.97	3.16
CaO	53.77	38.93
MgO	2.46	14.23
R_2O_3(Al, Fe, Mn)	.45	.97
CO_2	39.50	42.27
Alkalies + Ba	2.86	2.48

The analysis shows that the mottled areas are dolomitic, and that they contain more insoluble material. The irregular pattern of the markings, and thinning or fading of many of the mottles at their outer surfaces strongly suggest that the uneven dolomitization is caused either by the secondary infiltration of minerals, or, more probably, by the leaching out of those originally there.

In attempting to explain the peculiar dolomitization, the writer has considered the following: Evidence of solution is prevalent in the quarry rock. Vugs of varying size, stylolites, large cavities along joint planes, slump of beds, and insolubles remaining in the rock in the form of blue clay and shaly clay-like films are common. The light colored areas are less dense and not as hard as the mottled portions. The porosity of the light-colored rock suggests that leaching accounts for the partial disintegration.

The original rock was probably a slightly dolomitic limestone. Solution, either by sea water or ground water, leached the rock. Since descending ground waters are known to have a high calcium-magnesium ratio, the leaching probably took place after the sediments were uplifted. The percolating waters increased the relative amount of silica in the rock, and, by removing calcium, increased the relative percentage of magnesium. At the same time, the total volume of the rock was reduced. Thus, considerable calcium has been carried away, leaving the insolubles as clay-like films in irregular pattern throughout the rock, and dolomitic mottles as evidence of remaining partial dolomitization. It is realized that this view is the reverse

[1] Culver, H. E., Geology and mineral resources of the Morris Quadrangle: Illinois Geol. Surv. Bull. 43, pp. 115, 116, 1923.

[2] Payne, J. N., Subsurface geology of the Marseilles, Ottawa, and Streator quadrangles and vicinity; Ph.D. Thesis, Univ. Chicago, 1938.

of accepted theories of dolomitization, but the close association of solution and mottling lend support to this belief.

The writer has observed rocks of similar mottling at Dubuque, Iowa, Dixon and Belvidere, Illinois, Ft. Atkinson, Wisconsin, and Groos, Upper Michigan. The markings, however, are much less distinct, and are commonly deeper buff than the surrounding rock. At the above locations solution is not nearly so much in evidence, which fact may account for the less distinct marking of the rock.

Lithology.—The quarry may be divided roughly into two zones lithologically. (1) An upper, consisting of ten feet of platy, medium to coarsely crystalline limestone. Shales are not common. The color of the rock in this zone is light gray on a freshly fractured surface with a slight pinkish cast where the rock is more coarsely crystalline, but the weathered rock is buff. Red films often cover the fossil molds. Secondary calcite is plentiful in the strata and along the joints. Calcite vugs and pyrite are quite common. Small amounts of oil have been found at this horizon in the area south of Plainfield about 15 miles northeast of Central. The porosity of the rock in this zone makes it a possible reservoir for oil. (2) The lower 20 feet is a gray, dense, dolomitic limestone in which upper beds contain several well defined crystalline bands. The bands have an uneven surface at the base, are coarsely crystalline, and very fossiliferous. Many of the fossil fragments appear to have been macerated. The bands, ranging from two to four inches in thickness, grade into bands more finely crystalline above and change gradually upward to fine grained nearly lithographic limestone. Zone five of the measured section shows a one inch band of fine grained rock both above and below one of these bands.

In the lower division, thin shaly partings separate the massive beds. Also thin shaly films, referred to above (see mottling) are found without any definite pattern throughout the rock. These films, when exposed on a fresh fracture are dark gray, dark brown, or black. The rock gives off a fetid odor under the blow of a hammer.

CENTRAL QUARRY, SW. ¼ SEC. 28, T. 35 N., R. 7 E., MORRIS QUADRANGLE, ILLINOIS

		Feet	*Inches*
10.	Limestone, slabby, thin-bedded, gray, weathers buff; bedding surfaces uneven; iron stained in places, calcite vugs; very fossiliferous with *strophomena* profuse, *Illaenus* and *Isotelus*	7	3
9b.	Limestone, dark gray, pyritic, fossiliferous; beds three inches thick; more crystalline than No. 10	1	
9a.	Limestone, gray, thin-bedded, slabby, pyritic; calcite vugs	1	10
8d.	Limestone, gray, dense, fossiliferous; calcite vugs; crystalline band through center which is more coarsely crystalline below than above		7
8c.	Limestone, gray, fossiliferous, in two thin beds		7
8b.	Limestone, very fossiliferous, near coquina; weathers buff		2
8a.	Limestone, dolomitic, gray to dark gray, beds three to four inches thick, bedding surfaces uneven with carbonaceous films between the beds; prominent shaly parting at base; mottling of dark and light gray colors noticeable, but not prominent; dwarfed species of *Receptaculites* near the top	1	3
7b.	Limestone, dolomitic, gray, mottled, brittle; more massive than 8a	1	6
7a.	Shale, calcareous, dark gray, somewhat crystalline, carbonaceous; wavy laminated bedding, persistent as a marker; *Hormotoma* noted		2
6c.	Limestone, dolomitic, gray, mottled, fossiliferous		7
6b.	Limestone, dolomitic, similar to 6c but contains a gray-brown crystalline band which is coarse below grading to sublithographic limestone upward; base of the crystalline band is uneven		5
6a.	Limestone, dolomitic, gray, brittle, fossiliferous, in a massive bed	1	
5.	Limestone, dolomitic, gray, brittle, mottled, carbonaceous, massive; near lithographic at top and bottom of this unit	1	6
4.	Limestone, dolomitic, similar to No. 5 except that top for six inches is very crystalline; mottling pronounced	1	7
3b.	Limestone, dolomitic, gray, dense, massive, mottled		10
3a.	Limestone, dolomitic, similar to 3b; carbonaceous films on uneven and pitted bedding planes	3	
2.	Limestone, dolomitic, gray, dense, massive, somewhat mottled	1	
1.	Limestone, dolomitic, similar to No. 2; sparingly fossiliferous. *Hormotoma* and *Trochonema* present	7	6

Comparison with the Kimmswick limestone.

The Kimmswick of Missouri and western Illinois is a medium to massively-bedded, gray, crystalline, fossiliferous limestone. It is characterized by its lithologic uniformity. The rock at Central exhibits the following characteristics, which shows transitional relationships:

(1) A number of coarsely crystalline bands in the quarry section.
(2) The calcareous and not wholly dolomitic nature of the rock.
(3) Gray color with a pinkish tone in the upper beds.
(4) A fauna which compares closely.

USE OF THE GLEN DEAN LIMESTONE AS A STRUCTURAL KEY HORIZON IN THE ILLINOIS BASIN[1]

GEORGE V. COHEE[2]

Illinois State Geological Survey, Urbana, Illinois

The Glen Dean formation is one of the best known formations of the Chester series in Illinois. Since 1937 the basal limestone has been used widely as a structural key horizon and as a subsurface "marker" in drilling. The producing formations in most of the new oil fields in Illinois lie below the Glen Dean limestone, so the formation is penetrated by a great majority of the oil tests drilled within its boundary.

The formation was first described by Butts[3] in 1917 as follows: "The Glen Dean limestone is named from Glen Dean in the southern part of Breckinridge County, Kentucky. This name is adopted because of the excellent exposure of the limestone along the railroad on both sides of Glen Dean. It is composed of varying proportions of limestone and shale and includes locally, at least, a little sandstone. The bottom segment of the formation, at several widely separated points in Breckinridge County, is about 10 feet of green and red shale lying upon the flaggy Hardinsburg sandstone."

Figure 1 shows the subsurface and outcrop boundaries of the Chester series and the Glen Dean formation in Illinois and the thickness of the Glen Dean throughout its areal extent. Considerable variation in thickness is noted from north to south. Around the north end of the Illinois basin it is from 0 to 25 feet thick, and in Jackson County in southwestern Illinois it is more than 100 feet thick. A short distance to the east in Union County there is a pronounced thinning of the formation along the outcrop, but it thickens again to almost 100 feet in Johnson County. In the deep basin area in White, Hamilton, and Wayne counties, it is generally from 50-75 feet thick. Thinning of the formation occurs in areas of major structural features in the State, indicating some structural movement during late or post-Glen Dean time.

The Glen Dean formation in the Illinois basin is predominantly limestone with various amounts of shale. In many areas it consists of two limestone members, separated by calcareous shale, which are designated as upper and lower or "massive" Glen Dean. The upper limestone is very erratic in its distribution but the lower member is persistent and maintains a fairly uniform structural relationship with the underlying beds although there may be some local variation in its thickness. Both the top and base of this lower member are used as key horizons on which structure contour maps are based. The limestone is characteristically coarse-grained, crinoidal, oolitic, and brownish-gray. It contains a variable amount of chert and some dolomite. In most areas it is the highest limestone of the Chester series that contains well developed oolites. (Occasionally oolites occur in the higher Menard and Vienna formations.) In subsurface studies the top of the formation is placed at the top of the calcareous shale overlying the uppermost limestone and the bottom of the formation is placed at the base of the calcareous shale below the basal limestone member.

The Glen Dean is usually overlain by the Tar Springs formation, generally a massive sandstone which varies from 30 to 135 feet in thickness but in some areas it is principally shale or sandy shale. The Glen Dean formation is underlain by the Hardinsburg formation, which generally consists of shale and sandy shale or siltstone and is usually from 20 to 60 feet thick. Locally a well developed sandstone may occur within the Hardinsburg.

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[1] Published with the permission of the Chief, Illinois State Geological Survey.
[2] Now Assistant State Geologist, Dept. of Geology, Indianapolis, Ind.
[3] Butts, Charles, Description and Correlation of the Mississippian Formations of Western Kentucky: Kentucky Geol. Survey, 1917, p. 97.

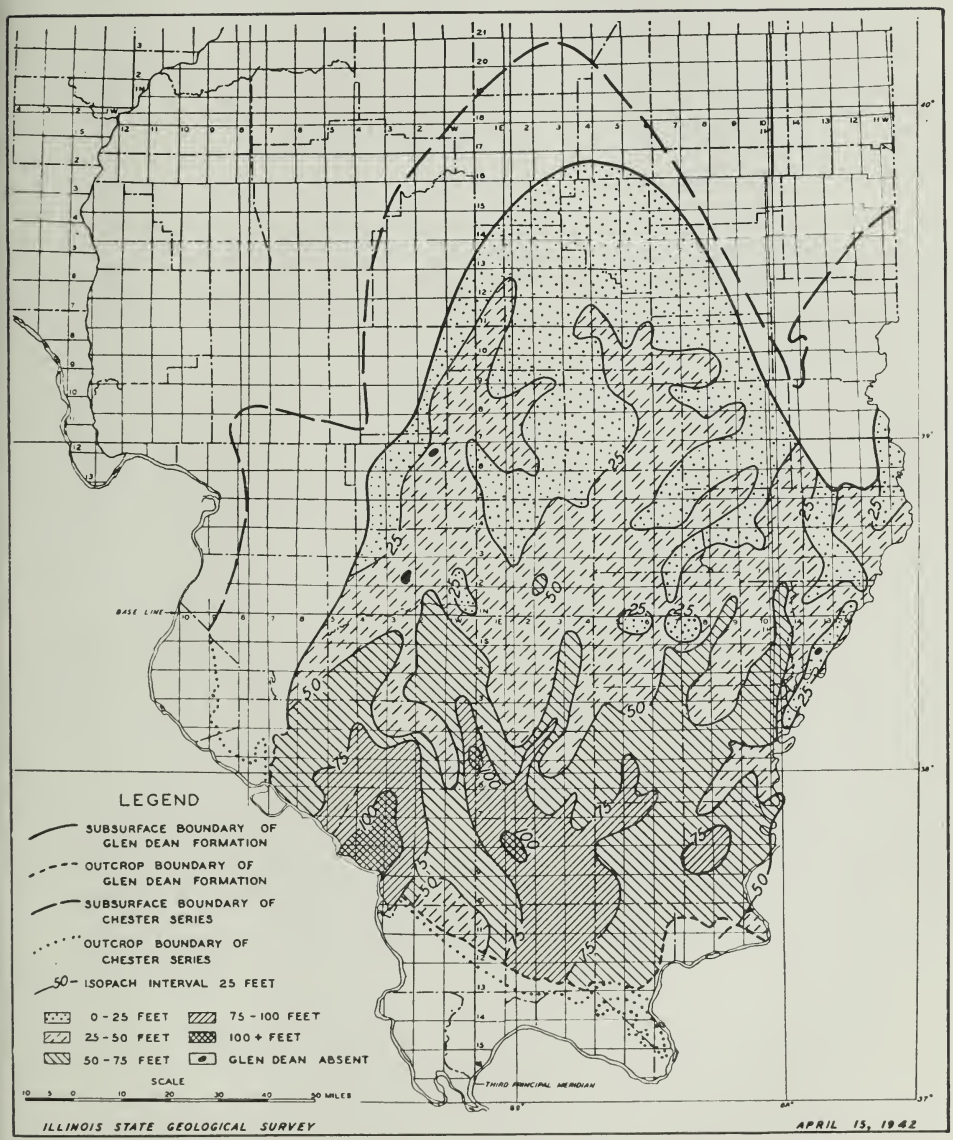

Fig. 1.—Thickness map of Glen Dean formation.

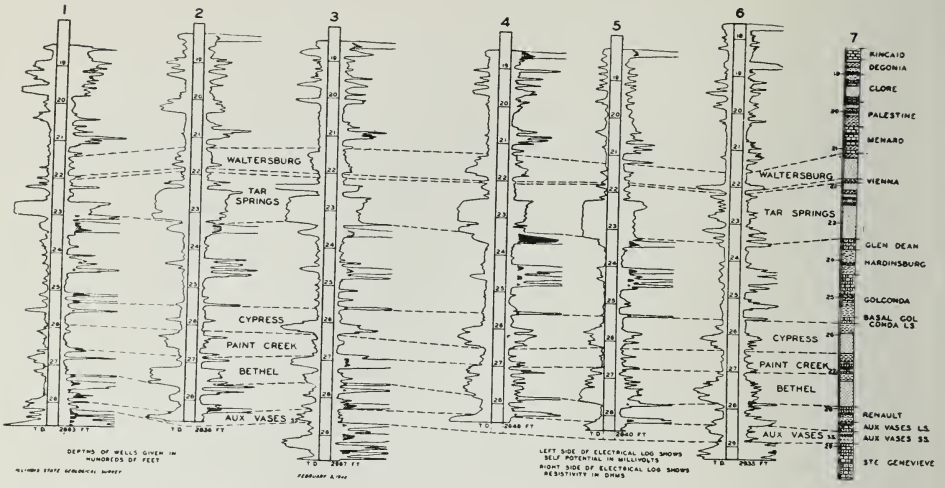

Fig. 2.—New Harmony Field. North-south electrical log cross-section

In various areas in the Illinois basin certain thin persistent limestone beds, such as the basal Golconda limestone, have proved more satisfactory than the Glen Dean for detailed structural information. In the New Harmony field of eastern White County the thin basal Golconda limestone is present throughout the area and is a better structural key horizon than the basal Glen Dean limestone which is slightly variable in thickness. Figure 2, a north-south electrical log cross-section in the New Harmony field, shows the variation in thickness of the Glen Dean formation in that area. The wells represented in the cross-section are about one mile apart. In wells one, three, and five of the cross-section, the upper Glen Dean limestone is present; however, it is best developed in well one. Only the lower or "massive" limestone occurs in the other wells of the cross-section. The "massive" limestone is poorly developed in well six. In the few areas where production is limited to that part of the Chester series above the Glen Dean, the basal Menard or the lower Kinkaid limestone, if present, are used for structural key horizons.

The Glen Dean formation is an important subsurface "marker" because it is usually recognized easily in electrical logs, in sample studies, and in drilling, and it is present over most of the area in southern Illinois where oil development and exploration is most active.

ACKNOWLEDGMENTS

The writer is grateful to Dr. A. H. Bell and other members of the Survey staff for helpful suggestions and criticism of the manuscript.

CHESTER INDEX OSTRACODES[1]

Chalmer L. Cooper

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The ostracodes constitute one of the most persistent orders of microfossils. Although many genera are extremely long lived, careful study reveals many species of value as index fossils. These forms have been found in all types of marine sediments throughout most of the Paleozoic era. Freshwater forms appeared with the change of the sedimentary conditions that resulted in the deposition of alternating marine and freshwater beds in the Pennsylvanian and Permian systems. The non-marine forms become important only in post-Paleozoic formations.

As shown by recent work[2] the Chester series has furnished one of the most diversified ostracode faunas of the Paleozoic era. Nearly 360 species are known and all but 35 are found in Illinois. This is a very marked increase over the number of species found in the lower Mississippian formations.

A few holdover genera from the Devonian period are present, but in greatly decreased numbers, namely *Beyrichia* and *Primitia*. The Chester series is characterized by a great increase in the number of species of *Bairdia, Cavellina, Glyptopleura, Healdia,* and *Paraparchites*. Genera restricted to the series are *Bairdiolites, Chesterella, Deloia, Geffenites, Glyptopleuroides, Lochriella, Paracavellina, Perprimitia,* and *Tetratylus*. Genera which continue into the Pennsylvanian era with little or no change in the number of species represented, are *Amphissites, Bythocypris, Ectodemites, Kirkbya,* and *Paraparchites*.

However, genera alone are of little value as stratigraphic indices. Only eight of the 67 genera known to occur in the Chester series are restricted to one formation, and five of these are represented by only one species each. More diagnostic species are found in the New Design (lower Chester) group than in the Homberg (middle Chester) and Elvira (upper Chester) groups. In the New Design group about half of the known species are restricted to one formation, whereas, approximately only a third of the species in each of the two higher groups are so restricted. The greatest change in the ostracode faunas occurs at the Homberg-Elvira boundary, dividing the Chester series into an equal number of formations above and below.

Some of the restricted species may not be good index fossils. Many of them are new and further work will no doubt increase their range. In some genera the species are so nearly alike that they are readily confused, and for this reason they are of little value for correlation. These include species of *Bairdia, Healdia, Cavellina,* and many species of the Amphissitinae.

[1] Published with permission of the Chief, Illinois State Geological Survey.
[2] Cooper, Chalmer L., Chester ostracodes of Illinois: Illinois Geol. Survey, Rept. Inv. 77, 101 pp., 14 pls., 1941.

THICKNESS OF GLACIAL DRIFT IN DU PAGE COUNTY, ILLINOIS[1]

A. C. Mason

Illinois State Geological Survey, Urbana, Illinois

A map showing the thickness of glacial drift in Du Page County has been prepared as an aid to the State Department of Public Health in their enforcement of water-supply and sewage-disposal regulations in those regions in which limestone and dolomite constitute the uppermost bedrock and the glacial drift is thin or absent. Water moving underground in limestone and dolomite may receive little or no filtration, and water from the surface recharging these formations is likely to be inadequately filtered unless it has passed through a sufficient thickness of glacial drift. Where less than 50 feet of glacial drift overlies limestone or dolomite from which municipal water supplies are obtained, the Department recommends continuous and adequate chlorination, or, under certain conditions, purification and chlorination. Where the drift is less than 30 feet thick, the Department recommends chlorination of private supplies. In addition, certain local sanitary units, such as township health boards, may permit no private septic-tank sewage disposal unless there is a minimum thickness of 30 feet of glacial drift to filter the effluent.

Du Page County is located directly west of Cook County and its eastern boundary is less than 5 miles from the western city limits of Chicago. It is a suburban region where water-supply and sewage-disposal problems are common, and it is the only county in Illinois in which all the bedrock at the surface or directly underlying the glacial drift is limestone and dolomite.

The thickness of the glacial drift is the resultant of the elevation of the bedrock surface, the amount of glacial deposition, and the extent of subsequent stream dissection. A contour map of the bedrock surface of Du Page County, based on data obtained from the logs of more than 600 wells in the county, shows that the bedrock surface in general slopes from an elevation of about 685 feet above sea-level in the northwest part of the county to an elevation of about 560 feet in the southeast corner where a trench in the bedrock has been cut by the Des Plaines River. The preglacial divide between east and southwest drainage appears to have crossed Du Page County from northwest to southeast, 10 to 15 miles west of the present drainage divide. Buried bedrock hills lie along the former drainage divide.

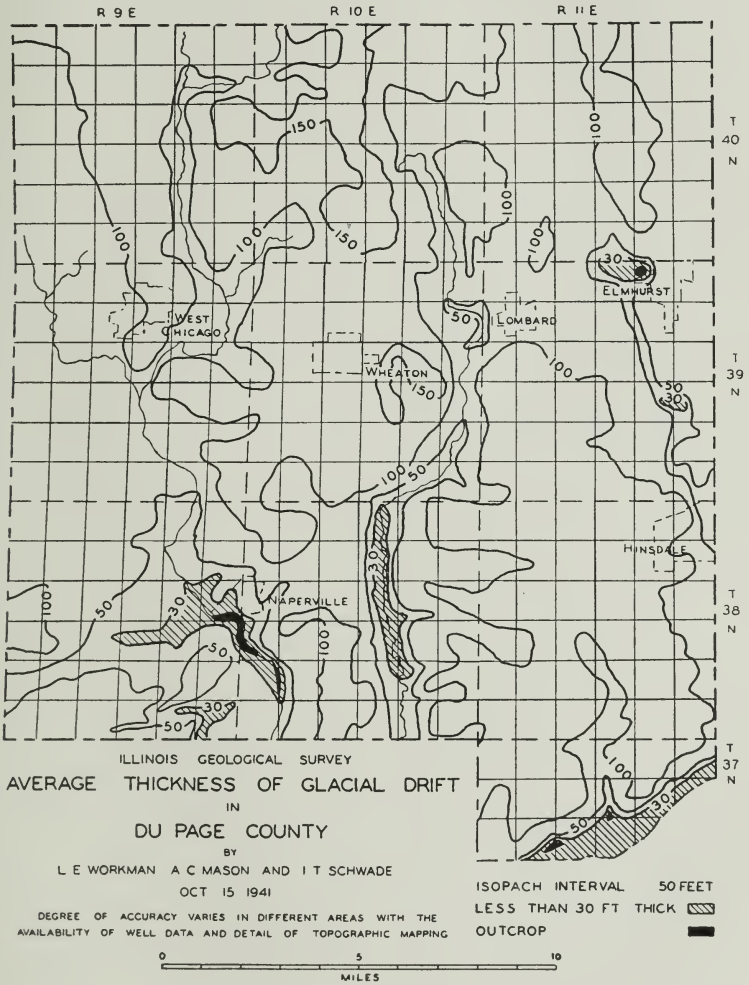
The present ground surface has a general slope towards the southeast, from an elevation of about 840 feet above sea-level near the northwest corner of the county to an elevation of about 590 feet in the southeast corner in the valley trench cut by the Des Plaines River. Standing about 50 to 90 feet above the general surface are a series of arcuate, somewhat discontinuous, morainic ridges trending north to south-southeast. The greater portion of the county is covered by the Valparaiso morainic system which on its west side includes the West Chicago moraine. Beginning near the west border of the county, the ground surface rises to the west towards Minooka Ridge. In the northeast corner of the county, the Tinley moraine forms a prominent ridge. The rest of the county is mostly covered by ground-moraine and outwash plains.

The map showing the average thickness of glacial drift in Du Page County has isopachous intervals of 50 feet, with inclusion of the 30-foot isopach because of its importance for sanitary engineering considerations. The relative accuracy of the map varies in accordance with the amount of data obtained, which in general is greater in the built-up areas. The thickness of the glacial drift varies from a maximum of about 175 feet in the north part of the county to nothing where bedrock crops out in small areas in the south and east parts of the county. The thick-

[1] Published with the permission of the Chief, Illinois State Geological Survey.

est drift is found in the north part of the county beneath the highest portions of the West Chicago moraine and the undifferentiated Valparaiso moraine. The drift is less than 30 feet thick where streams have cut into thin ground moraine overlying bedrock hills. These areas are in the vicinity of the West Branch Du Page River near Naperville, the East Branch Du Page River near Lisle, and Salt Creek near and south of Elmhurst. Bedrock is exposed near Naperville and in a quarry at Elmhurst. The drift is also less than 30 feet thick in Des Plaines River valley, where bedrock is exposed in quarries and at points along the hillside.

In approximately 90 per cent of the 345 square miles of area of Du Page County the drift is more than 50 feet thick, and in approximately half the county the drift is more than 100 feet thick.



BITUMINOUS MATTER IN WARSAW GEODES

PERCIVAL ROBERTSON

The Principia College, Elsah, Illinois

In 1922 Van Tuyle[1] called attention to the geodes found in the Keokuk and lower Warsaw beds in this language: "Apart from Professor Brush's preliminary examination and description of a few select specimens submitted to him in 1865 by A. H. Worthen, then director of the Geological Survey of Illinois, no study of these remarkable geodes has ever been made, in spite of the fact that they bear a variety of metallic sulphides and promise to throw some light upon the origin of more important deposits of these materials in sedimentary rocks which show no signs of igenous influence." In addition to the sulphides, Van Tuyl later called attention to another very interesting phenomena connected with the geodes, namely the occurrence of a black bituminous matter. He wrote, "The geodes from the lower part of the Lower Warsaw at several localities near Niota, Illinois, are strikingly contrasted to those in other occurrences in that many of them are partly or completely filled with a black viscous bitumen. The fact that such bituminous geodes occur in a non-bituminous shale and may be found in close proximity to ordinary geodes which show no trace of bitumen, lends to this feature still greater interest. As a general rule, however, the regular hollow geodes which occur in the same layers with bituminous types show at least a black stain in their chalcedonic shells."

A few years ago Mr. Thayer Gruner, then a graduate student at Washington University, called the author's attention to the appearance of bituminous matter in what he described as "vugs" in the Alto formation a few miles south of Jonesboro, Illinois, specifically along the south line of the NW ¼ sec. 1, T. 13 S., R. 2 W., in the eroded bank of a small tributary of Dutch Creek. The vugs that Mr. Gruner described are crystal lined cavities found in the interior of siliceous concretions. These concretions could probably be called geodes, although we were not able to ascertain if they actually weathered out of the limestone and formed the familiar rounded pebbles or cobbles that most people usually think of when we use the term geode.

With these two occurrences of petroleum-like masses in geodes it appeared that there might be value in examining more precisely some of the chemical and physical properties of the bituminous matter and determining if there was any marked similarity between the bituminous matter found in these geodes and petroleum found elsewhere in the state. To this end about fifty petroleum-bearing geodes were collected from near Niota. The oil is usually a black tarry matter, so viscous that it will just about flow. We were able to collect enough of the material in this way for our determinations. However, we were able to collect only a few, eight or ten, of the geodes from the Alto formation and found bituminous matter to be, in these instances, merely a black mass lining parts of the geode cavity. It may be interesting to note in passing that small crystals of sphalerite were found in several of these bituminous-bearing geodes. In an attempt to obtain the bituminous matter we first distilled small amounts directly from the broken fragments of the geodes but were able to collect a few drops of viscous matter resembling a very soft paraffine, neither quite liquid nor quite solid. The color was dark but not black. Not obtaining a sufficiently large sample in this way, the balance of the geodes were broken up into small pieces, placed in a Soxhlet apparatus and extracted with carbon tetrachloride. The latter being distilled off, there remained a black, nearly solid mass of bituminous material which provided the samples for most but not all of the analyses performed.

For the purpose of comparison we obtained samples of petroleum from the Colmar-Plymouth oil field through the

[1] "The Stratigraphy of the Mississippian Formations of Iowa," *Iowa Geological Survey*, Annual Reports 1921-22, Vol. XXX.

TABLE I.—PROPERTIES OF BITUMENS ANALYZED

	Crude oil from Colmar oil field	Topped residue from Colmar oil field	In geodes in Warsaw formation from near Niota, Ill.	In geodes in Alto formation from near Jonesboro
Carbon percent	82.68	85.58	82.83	86.4
Hydrogen percent	*13.23*	*11.93*	*15.71*	*11.2*
	95.91	97.51	98.54	97.6
Iodine number	21.0	21.0	29.0	50.0
Halogen content	trace	trace	trace	trace
Sulfur content	none	none	none	none
Specific gravity	0.867	0.902	0.785	0.895
Refractive index	1.4105	1.4100	1.425	1.534
Boiling point		110°C.	107°C.	109°C.
		10 mm.	7 mm.	20 mm.
Solubility in carbon tetrachloride		sol.	sol.	sol.

courtesy of Mr. O. C. Ackman of the Ohio Oil Company. The oil here is found in the relatively shallow depth Hoing sand of Silurian age. This particular oil was selected because it was the nearest oil field to the Niota locality, being less than thirty miles away. We determined first the boiling point of the bitumen in the Warsaw geodes, and distilled the petroleum, rejecting all of the faction that boiled below the boiling point of the oil found in the geodes. The results shown in Table I were then obtained from the three bituminous residues.

From these results it becomes evident that there is marked similarity between the bitumen in the geodes from both Niota and Jonesboro and the topped oil from Colmar. They were paraffins of relatively high molecular weight. There are only negligible amounts of unsaturated hydrocarbons in all three. The geode oils show practically no halogen. The original sample of crude oil from Colmar contained a small amount of salt water. No traces of sulfur were found. The specific gravity is slightly high in all cases except for very high boiling point paraffin, (Hexadecane has a specific gravity of 0.775), but the refractive index and boiling points, (the latter taken under reduced pressure to avoid cracking as much as possible) correspond closely to those reported for paraffin hydrocarbons of high molecular weight.

In general the Alto geodes, appear to have lost more volatile material than the Warsaw ones. It seems reasonable to assume that the oils have at least similar sources and that they have been subjected to similar conditions affecting their formation, the Alto geodes having lost somewhat more of their volatile fraction.

The problem of migration of the oil into the geode is more difficult. Any assumption of original oil in the geode appears fantastic. We have found that the Warsaw formation where in contact with oil bearing geodes is quite saturated with petroleum in one locality, specifically along the south bank of Tyson creek about where it intersects the south edge of sec. 15, T. 7 N., R. 8 W., south of Niota, Illinois.

The chalcedony geode shell, and more particularly the shale layer immediately in contact with it are very impervious. Dr. Norris Johnston of the General Petroleum Corporation of California reports in a private communication that the air permeability of the geode walls run from 0.03 to 0.37 millidarcies, while that of a characteristic sample of Warsaw shale from the same horizon as the geodes was 0.54 millidarcies.

While the main part of the geode walls are highly impervious, in breaking some geodes there seem to be minute cracks or capillary tubes thru which the oil may have penetrated. There are sometimes seen fine black lines of oil extending from the center of some geodes to, or nearly to, the outer edge of the chalcedony shell. If oil was under considerable pressure in the rocks, it would probably find it easier to compress the gas contained within the geodes passing through the few capillary openings than to overcome the resistance of passage through the only very slightly pervious shale. We suspect the unusual imperviousness of the shale directly surrounding the geode is an important bit of evidence regarding the origin of the geodes themselves.

Conclusion: The bituminous matter in geodes found in the Warsaw formation

in the vicinity of Niota, Illinois, and in geodes found in the Alto formation a few miles south of Jonesboro, Illinois, is similar in some of its chemical and physical properties to petroleum found in the Hoing sand at Colmar, Illinois, except that the materials in the geodes have less of the more volatile hydrocarbons. The shale in contact with some bituminous bearing geodes is itself oil-bearing in at least one locality. The oil would find the shell of the geode in general difficult to penetrate, but there are capillary passages that would afford a passage to the interior of the geode.

SUBSURFACE STRATIGRAPHIC SECTIONS NEAR TYPE CHESTER LOCALITIES IN SOUTHWESTERN ILLINOIS[1]

Frank E. Tippie

Illinois State Geological Survey, Urbana, Illinois

Introduction.—The correlation of the Chester formations in southwestern Illinois has been greatly aided by the study of cuttings from wells which are located near the type localities of these formations. Descriptions of outcrops and well cuttings agree closely. Most outcrops do not expose a complete formation and its relationship to formations above and below it. Therefore, subsurface stratigraphic sections of seven Chester formations having type localities in southwestern Illinois are presented to enable geologists to observe these relations and make direct comparisons with other stratigraphic sections.

Aux Vases Sandstone.—In 1892, C. R. Keyes (1, p. 298)[2] proposed the name Aux Vases for the "ferruginous sandstone" described by Shumard, typically exposed at the mouth of Aux Vases Creek, Ste. Genevieve County, Missouri. The Aux Vases sandstone is now recognized as the basal formation of the Chester series. It overlies the Ste. Genevieve limestone unconformably and is in turn overlain by the Renault formation.

In the type locality the Aux Vases (4, p. 229) formation consists of two zones, each 18 feet thick. The lower zone is made up of interbedded variegated shales and sandstones, and the upper is massive fine-grained sandstone. It is overlain by the Renault formation, consisting of 2 to 4 feet of sandstone and sandy green clay overlain by purple shales.

The Anderson-Cassoutt No. 1 well (fig. 1B) is located 7 miles east of the type locality of the Aux Vases sandstone. In this well the Aux Vases is represented by 56 feet of fine-grained to coarse-grained angular sandstone. The base is a sandstone conglomerate containing pink and white chert and a few limestone fragments. This is indicative of the unconformity recognized at the base of the Aux Vases formation. The Aux Vases becomes increasingly finer-grained upward. It is here overlain by very fine-grained pink pyritic sandstone and interbedded variegated shales of the Renault formation.

Renault Formation.—Stuart Weller (2, pp. 122-124) proposed the name Renault for the series of limestones, sandstones, and variegated shales that lie above the Brewerville, now the Aux Vases sandstone, and below the Yankeetown chert. The Renault formation is typically developed along the tributary to Dry Fork of Horse Creek in sec. 23, T. 4 S., R. 9 W., Monroe County, Illinois, and consists of the following zones in ascending order (5):

(4) 5 feet of limestone with some shale partings.
(3) 15 feet of calcareous fossiliferous shale with numerous thin limestone layers.
(2) 2 to 3 feet of arenaceous limestone.
(1) 3 feet of massive sandstone.

The Renault formation as represented in the Ames-Nicholson No. 1 well (fig. 2A), located 4 miles south of the type locality, is, in part, almost identical. Zone 1 of the outcrop is represented in the well by 23 feet of yellow and greenish partly spotted reddish-brown, very fine-grained compact sandstone with a few thin stringers of sandy limestone and greenish-gray and purple shales; Zone 2 by 5 feet of sandy limestone; Zone 3 by 24 feet of red, purple, and gray calcareous shale, interbedded with very calcareous siltstone; and Zone 4 by 7 feet of cherty coarsely crystalline green limestone and white lithographic limestone.

Yankeetown Chert.—The Yankeetown formation (2, pp. 124-125) is a hard per-

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[2] Numbers in parentheses refer to references at end of article.

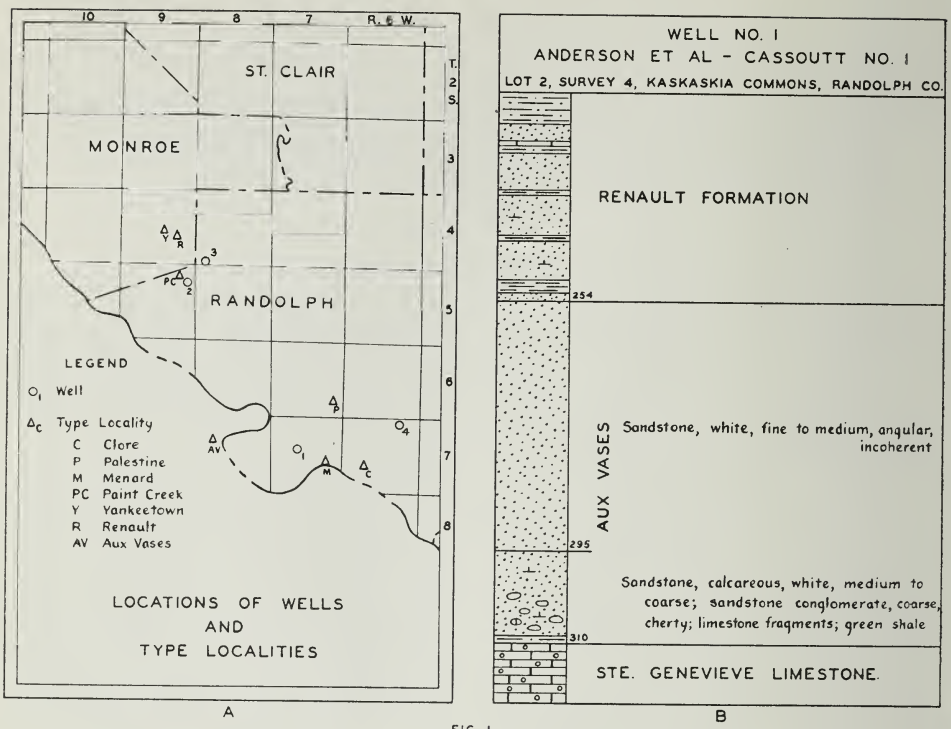

FIG. 1

sistent siliceous stratum, typically developed as an arenaceous chert near Yankeetown School in southeastern Monroe County, Illinois.

Only a few subsurface records show the Yankeetown chert in its typical outcrop form. In the Ames-Nicholson No. 1 well, 5 miles southeast of the type locality, the Yankeetown formation is represented by a sandy chert in the lower 16 feet and by a slightly calcareous chert in the upper 7 feet. A few miles to the east of the outcrop belt, the Yankeetown formation becomes a very fine-grained sandstone that continues into the Illinois basin.

Paint Creek Formation.—The name Paint Creek (2, pp. 125-126) was proposed by Stuart Weller for the red shale and limestone above the Yankeetown chert and below the variegated shales and sandstone of the Ruma formation. The Paint Creek formation is typically developed along the tributary to Paint Creek in sec. 2, T. 5 S., R. 9 W., Randolph County, Illinois. Weller recognized two zones of the Paint Creek: The lower zone consists of 20 to 25 feet of deep red clay with a few limestone nodules; the upper zone is more calcareous and shaly below, grades upward into more massive limestone beds, and totals 30 to 40 feet in thickness. In 1920, Weller (3, p. 298) extended the Paint Creek to include the variegated shales in the lower part of the Ruma formation and suggested that the name Ruma be discontinued as a formation name. This would establish a third zone in the Paint Creek.

In the composite log of the Ames-Nicholson No. 1 and the Haverstick-Dashner wells, respectively one mile southeast and two miles northeast of the type locality, all three zones are present. The lower red shale zone with limestone nodules is 28 feet thick. The middle limestone zone consists of a lowermost sub-lithographic limestone 15 feet thick, a middle sandy limestone 15 feet thick, and an uppermost light brown and pink, partly oolitic and partly coarsely crystalline limestone 12 feet thick. The third zone is 12 feet of variegated shale.

An additional zone, not noted in outcrops but generally recorded in wells, is a thin very fine-grained sandstone or silt-

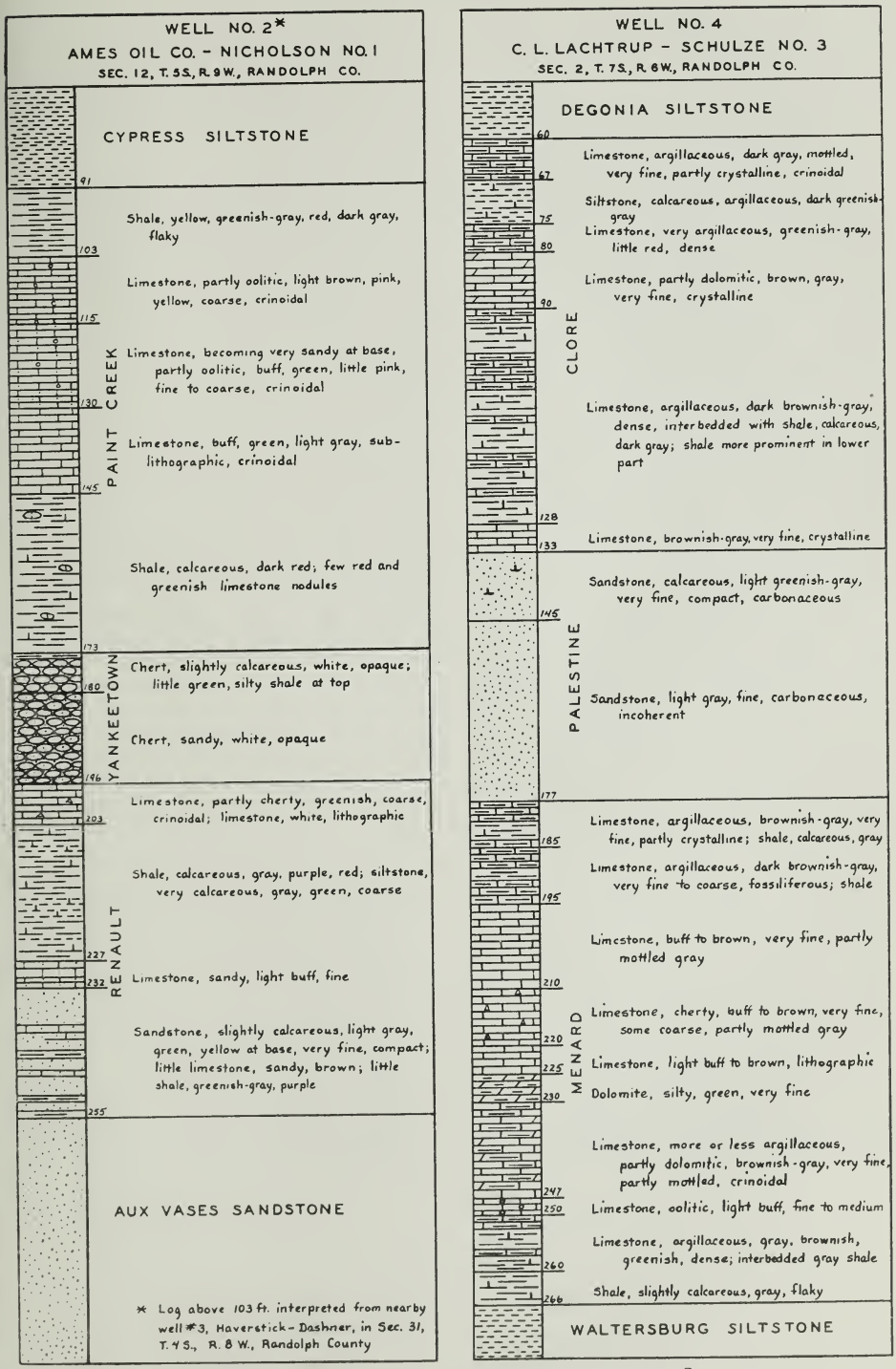
WELL NO. 2*
AMES OIL CO. - NICHOLSON NO. 1
SEC. 12, T. 5S., R. 9W., RANDOLPH CO.
CYPRESS SILTSTONE
91
Shale, yellow, greenish-gray, red, dark gray, flaky
103
Limestone, partly oolitic, light brown, pink, yellow, coarse, crinoidal
115
PAINT CREEK
Limestone, becoming very sandy at base, partly oolitic, buff, green, little pink, fine to coarse, crinoidal
130
Limestone, buff, green, light gray, sub-lithographic, crinoidal
145
Shale, calcareous, dark red; few red and greenish limestone nodules
173
YANKEETOWN
Chert, slightly calcareous, white, opaque; little green, silty shale at top
180
Chert, sandy, white, opaque
196
Limestone, partly cherty, greenish, coarse, crinoidal; limestone, white, lithographic
203
Shale, calcareous, gray, purple, red; siltstone, very calcareous, gray, green, coarse
227
RENAULT
232
Limestone, sandy, light buff, fine
Sandstone, slightly calcareous, light gray, green, yellow at base, very fine, compact; little limestone, sandy, brown; little shale, greenish-gray, purple
255
AUX VASES SANDSTONE
* Log above 103 ft. interpreted from nearby well #3, Haverstick - Dashner, in Sec. 31, T. 4 S., R. 8 W., Randolph County
A
WELL NO. 4
C. L. LACHTRUP - SCHULZE NO. 3
SEC. 2, T. 7S., R. 6W., RANDOLPH CO.
DEGONIA SILTSTONE
60
Limestone, argillaceous, dark gray, mottled, very fine, partly crystalline, crinoidal
67
Siltstone, calcareous, argillaceous, dark greenish-gray
75
Limestone, very argillaceous, greenish-gray, little red, dense
80
Limestone, partly dolomitic, brown, gray, very fine, crystalline
90
CLORE
Limestone, argillaceous, dark brownish-gray, dense, interbedded with shale, calcareous, dark gray; shale more prominent in lower part
128
133
Limestone, brownish-gray, very fine, crystalline
Sandstone, calcareous, light greenish-gray, very fine, compact, carbonaceous
145
PALESTINE
Sandstone, light gray, fine, carbonaceous, incoherent
177
Limestone, argillaceous, brownish-gray, very fine, partly crystalline; shale, calcareous, gray
185
Limestone, argillaceous, dark brownish-gray, very fine to coarse, fossiliferous; shale
195
Limestone, buff to brown, very fine, partly mottled gray
210
MENARD
Limestone, cherty, buff to brown, very fine, some coarse, partly mottled gray
220
Limestone, light buff to brown, lithographic
225
Dolomite, silty, green, very fine
230
Limestone, more or less argillaceous, partly dolomitic, brownish-gray, very fine, partly mottled, crinoidal
247
250
Limestone, oolitic, light buff, fine to medium
Limestone, argillaceous, gray, brownish, greenish, dense; interbedded gray shale
260
Shale, slightly calcareous, gray, flaky
266
WALTERSBURG SILTSTONE
B

FIG. 2

stone that occurs directly above the red nodular shale. However, this sandstone is not present in the Ames-Nicholson No. 1 well.

Menard Formation.—The name Menard (2, p. 128) was proposed for the moderately thick-bedded limestone with numerous shale partings, typically exposed in the Mississippi River bluffs at Menard in Randolph County, Illinois. In the outcrop the limestones are generally bluish-gray, close-textured, and fine-grained and often have a small amount of chert. Coarsely crystalline limestones may be common locally, but they are usually relatively thin and occur in the upper part of the formation. The lower part of the Menard is usually marked by a dark gray shale with thin limestone streaks.

The Lachtrup-Schulze No. 1 well (fig. 2B), 7 miles northeast of the type locality, exhibits a fairly typical Menard succession. At the base is 16 feet of shale and argillaceous limestone. Above this is a 3-foot oolitic limestone followed by 17 feet of more or less argillaceous limestone. The next lithologic unit is 35 feet of light brown, very fine-grained partly crystalline limestone. The lower five feet of this unit is a silty green dolomite whose lateral extent is not known, and for this reason the dolomite is not considered a separate unit. Chert is present at depths between 210 and 220 feet. The top of the Menard is 18 feet of fossiliferous shaly limestone and dark gray shale. The limestone is generally very fine-grained but some is coarsely crystalline.

Palestine Sandstone.—The Palestine sandstone (2, pp. 128-129) was so named because its type exposures are in Palestine Township, Randolph County, Illinois. It consists in part of heavy beds of sandstone and in part of thinly bedded sandstones or arenaceous shales.

In well No. 4, located about six miles east of the type locality, the Palestine formation consists of two zones: a lower light gray fine-grained incoherent and carbonaceous sandstone 32 feet thick, and an upper light greenish-gray very fine-grained calcareous carbonaceous and compact sandstone 12 feet thick. Arenaceous shales are not shown in sample cuttings from this well.

Clore Formation.—The name Clore (2, p. 129) was applied to a series of interbedded limestones and shales that overlie the Palestine sandstone and crop out near Clore School in Randolph County, Illinois. In many places the Clore includes much more shale than limestone. The shales are generally calcareous and dark in color. The limestones are variable, grading from dense argillaceous limestone to crystalline limestone.

In well No. 3, located about four miles northeast of the type locality, the Clore formation is represented by 5 feet of a very finely crystalline limestone at the base, overlain by 38 feet of dark gray calcareous shale interbedded with dark gray shaly limestone, the shale content decreasing upward. Above this shaly zone is 10 feet of brown very finely crystalline limestone overlain by 5 feet of very argillaceous greenish-gray limestone. A few fragments of this limestone in the cuttings are red. The next unit consists of a dark greenish-gray calcareous and argillaceous siltstone, 8 feet thick. The top of the Clore is 7 feet of mottled gray, crinoidal limestone.

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4. Weller, Stuart, Geology of the Ste. Genevieve County, Missouri: Mo. Bur. of Geology and Mines, vol. XXII, 2nd ser., 1928.
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RHYTHMS IN UPPER PENNSYLVANIAN CYCLOTHEMS[1]

J. Marvin Weller

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The concept of cyclothems is familiar to most geologists who have been concerned with the stratigraphy of the Pennsylvanian system in Illinois during recent years. The characteristic repetitions of different types of strata that make up a cyclothem are not, however, the only rhythms occurring in this system. In the McLeansboro group, particularly, complete cyclothems of different types succeed one another in a definite order that is repeated at least three times. These major rhythms or cycles of cyclothems, because of their similarity to one another, have caused confusion in the field that has undoubtedly resulted in miscorrelations at some places where outcrops are not abundant or adequately connected. When they are properly understood and worked out, however, they may furnish the basis for a new classification of the Illinois Pennsylvanian in which the cyclothems are joined into groups and series that are of more significance stratigraphically and historically than the ones now recognized. It is also possible that these larger rhythms may be the long-sought key that will solve some of the perplexing problems of interbasin correlation.

The succession of cyclothems that are now recognized in the McLeansboro is as shown in table I.

These cyclothems are arranged in six groups. The lower two are incomplete and more or less doubtful, but above the base of the Trivoli cyclothem, which is the boundary between the Des Moines and Missouri series of the Midcontinent region, the repetition of four general types of cyclothems is conspicuous. The highest group is represented only by a single basal cyclothem.

(a) The basal cyclothems of these groups are well developed. They possess prominent basal sandstones that appear to be separated from underlying beds by unconformities that at least locally are more than ordinarily well marked. Coal is generally present and may be locally workable on a small scale. Black sheety shale is conspicuously present at many places and is both underlain and overlain by lenticular, dark colored, and very impure marine limestone of similar lithology. The upper gray shale member of these cyclothems is generally thick.

(b) Cyclothems of the second type are very imperfect or even rudimentary and their presence is generally indicated only by a more or less persistent horizon of marine fossils that may be limestone (Collinsville), sandstone (Collinsville, Upper Macoupin), or ironstone (Upper Newton).

(c) Cyclothems of the third type are, like the first, well developed but their characteristics are quite different. Good basal sandstones are present. "Freshwater" limestones are rare and coal seams are thin or absent. Black slaty shale occurs in the Shoal Creek cyclothem but is missing in the LaSalle and Omega cyclothems. The upper marine limestones of these cyclothems are light colored,

TABLE I

	Name of Cyclothem	*Type*
23	Shumway	a
22	Woodbury	d
21	Gila	d
20	Omega or Greenup	c
19	Upper Newton	b
18	Newton	a
17	Upper Bogota	d
16	Lower Bogota	d
15	Cohn	d
14	Upper Livingston "La Salle"	c
13	Lower Livingston "La Salle"	c
12	Upper Macoupin	b
11	Macoupin	a
10	Flannigan	d
9	Shoal Creek	c
8	Collinsville	b
7	Trivoli	a
6	Exline	d
5	Gimlet	c
4	Sparland	a?
3	Bankston Fork	d?
2	Jamestown	c?
1	Brereton (part)	c

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comparatively pure, and massive. They have been quarried at many places and are probably the most conspicuous beds in the upper part of the Pennsylvanian system in Illinois. The upper gray shale members are generally of only average thickness.

(d) Cyclothems of the last type are thin and incomplete and their marine members commonly contain brackish-water rather than truly marine fossils. On the whole they are difficult to recognize because of their variability and lack of distinguishing characters. Some of these cyclothems include very prominent "fresh-water" limestones of various kinds. Some have well developed black slaty shale members that locally attain unusual thickness. Coals are generally thin or absent although in one area coal in the Flannigan is mined in a small way. Truly marine limestones are thin or absent, and the commonest fossils are *Estheria* and ostracodes in the black shales.

Of the three recognized groups of cyclothems above the Trivoli, the first is the simplest with only one cyclothem of each type and the second is the most complex with two cyclothems of the third type and at least three of the fourth.

Field work suggests that the Omega limestone of Marion County and the greenup limestone of Cumberland County are equivalent but the fusulines occurring in these beds are different, and those of the Greenup are believed by Dunbar and Henbest to be much younger. If these limestones have been miscorrelated, a fourth group of cyclothems, including the Omega, is probably present between the Upper Bogota and Newton cyclothems.

FOSSILIFEROUS ZONES OF THE UPPER PENNSYLVANIAN OF VERMILION AND EDGAR COUNTIES, ILLINOIS

Geo. M. Wilson

University of Illinois, Urbana, Illinois

The McLeansboro (Upper Pennsylvanian) in Vermilion and Edgar counties in eastern Illinois is exposed along Vermilion River and Brouillet Creek and their tributaries. The McLeansboro has been sub-divided into the following cyclothems (ascending order): Sparland, Gimlet, Trivoli, Shoal Creek, Flannigan, Macoupin, and Livingston. The composite section in Vermilion County includes about 300 feet of strata and in Edgar County nearly 400 feet. The regional dip of the strata is to the southwest. The names of the various cyclothems have been previously assigned by other workers. Further detailed study of the fauna of these cyclothems may prove or disprove their correlation with their type sections in other parts of the state.

In general the strata consists of shale, sandstone, limestone, underclay, coal, and conglomerate in about that order of abundance. Marine invertebrate fossils occur in strata above the coal zones of each cyclothem, and in calcareous sandstones below the coal in a few instances. Plant remains have been found in a few places in shale, sandstone, and limestone. Land vertebrate fossils were collected many years ago from reddish shales in the lower part of the Shoal Creek cyclothem in Vermilion County, and erroneously referred to the Permian. Marine fossils occur in greatest abundance in the limestones, and in decreasing abundance in the calcareous shales, black fissile shales, limestone conglomerates, and sandstones.

The megascopic fossils indicate a wide range of ecological conditions. They are very abundant in most of the marine members of the cyclothems. The most common genera are: *Dictyoclostus, Neospirifer, Composita, Juresania, Linoproductus, Lophophyllum, Sphaerodoma, Meekospira, Naticopsis, Bellerophon, Pharkodonotus, Euphemites, Myalina, Allorisma, Schizodus, Astartella, Pinna,* and many others. Several trilobites have been found in the Macoupin.

The ostracods are the most common of the micro-fossils and will, when further study is made, be of considerable value in correlation of the Pennsylvanian in Illinois. For example, *Geisina gregaria* has been found only in the Trivoli in Vermilion County. It is known to occur at

the same stratigraphic position in Peoria County. This form was originally described in 1906 from the Kansas City group of Kansas and called *Beyrichiella gregaria.* It is probable that other forms will be of equal value when their stratigraphic ranges have been determined. The dominant ostracod genera vary between cyclothems. The most common genera listed in the order of abundance are: *Bairdia, Cavellina, Hollinella, Amphissites, Kirkbya, Bythocypris, Geisina, Jonesina,* and *Kelletina.*

Foraminifera occur throughout the McLeansboro section. One of the important forms is *Triticites irregularis,* which has been found also in the Winterset beds of Iowa. This form occurs in a shale parting in the Livingston limestone. Other common foraminifera are: *Ammodiscus, Tetrataxis, Ammovertella, Polytaxis,* and *Glyphostomella. Glyphostomella triloculina* thus far has been obtained from only the Macoupin.

Conodonts have been found in several zones, even from the uppermost sandstone in the Vermilion County section.

In the Sparland, at the base of the thick marine shale, may be found an irregular black fissile shale that bears a pyritized, dwarfed fauna. Gastropods abound, with lesser numbers of brachiopods, pelecypods, some cephalopods, and ostracods. The overlying shale contains varying amounts of megascopic fossils, especially pelecypods.

The Gimlet in Vermilion County is represented by a thin basal sandstone and a limestone conglomerate, while in Edgar County there has been an addition of several members to the cycle and a thickening of the strata to nearly 90 feet. The limestone conglomerate is found in Edgar County also. It is of marine origin apparently, for in it there are crinoid stems, shark teeth, brachiopods, and bryozoa. In some areas it contains microfossils in the shales.

The Trivoli in Vermilion County yields largely micro-fossils, while in Edgar County it contains large numbers of megascopic, as well as microscopic fossils. The marine shale immediately overlying the coal zone in Vermilion County may be divided into two distinct zones on the basis of the micro-fauna.

The Shoal Creek in Vermilion County contains fossils in the nodular lime. In Edgar County there is an expansion of this cycle and a corresponding increase in the number of forms.

The Flannigan yields large numbers of microscopic as well as a large megascopic fauna. The members of the cyclothem are more completely developed in Edgar County.

The Macoupin is ideally exposed along Salt Fork of Vermilion River in Vermilion County. At the base there is a sandstone which grades upward into a siltstone. This is succeeded by a fresh water limestone at the base of the underclay immediately below a coal. The coal is immediately overlain by a black fissile shale. The black fissile shale grades upward into a dark carbonaceous, fossiliferous shale. The limestone varies from pure crystalline to argillaceous, and is very fossiliferous, containing large numbers of both megascopic and microscopic fossils. The overlying shale contains fossils also.

The basal sandstone of the Livingston cyclothem in Vermilion County is exposed along the Salt Fork. The black shale, an overlying blue shale, and limestone have been exposed in the Fairmount quarry. In Edgar County there is a continuous section along Brouillet Creek. The basal sandstone contains *Lingula* and *Aviculopecten.* The black shale overlying the coal and the green shale at the base of the limestone bear conodonts. The limestone here is tentatively correlated with the one in Vermilion County. It is from the shale partings in this limestone that *Triticties irregularis,* has been collected.

Although the general strategraphic succession has been studied, this is the first detailed study of the fauna that has been undertaken.

Papers in Physics

From the Report of the Section Chairman

Twelve papers were presented at the Urbana meeting, one of which, *The Betatron,* by D. W. Kerst, was published in the September issue of the *Transactions,* and five of which are published herewith. The others were:

Ewert, W. E., Chicago.—*Meteorology. A new method of long range weather forecasting.*

Wall, C. N., North Central College, Naperville.—*The inverted pendulum.*

Kibort, V., University of Chicago.—*Color vision.*

Ewert, W. C., Chicago.—*Falling bodies and the cause of gravity.*

Phillips, Theodore, Wright Junior College, Chicago.—*An outline of a physics course related to the C. A. A. program.*

Reed, C. I., and B. P. Reed, University of Illinois College of Medicine, Chicago.—*X-ray diffraction studies on physiological changes in bone.*

Maximum attendance was 70. Chairman for the 1943 meeting at Jacksonville, as elected, is F. W. Cooke, Illinois College, Jacksonville, Illinois.

(Signed) Frank L. Verwiebe, *Chairman*

A DEMONSTRATION RADIO SET

A. F. Inglis

University of Chicago, Chicago, Illinois

The demonstration radio set to be described here was built to make the transition between the circuit diagram and the actual circuit easier for the beginning student, and to provide a working model with which the function of each stage of a radio set could be readily demonstrated. All the wiring and all the parts of the set are placed on the top side of the mounting board, and as far as possible the layout of the wires corresponds to that on a conventional circuit diagram. Thus the function of each connection is made immediately apparent to the student. See fig. 1.

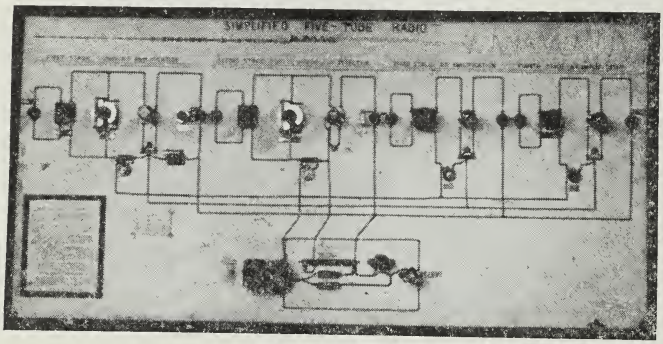


Fig. 1.

The radio employs a tuned radio frequency circuit since it was felt that the importance of the superheterodyne principle to the beginning student was not sufficient to warrant the added complication in the construction of the set. The model has four stages: a tuned radio frequency amplifier stage using a type 26 tube; a combined tuned radio frequency amplifier and detector stage using a type 27 tube; an audio frequency amplifier stage employing a type 26 tube; the power amplifier stage employing a type 71A tube. There are two tuning condensers which must be adjusted separately. Transformer coupling is used the audio frequency section. Sufficient power is developed to operate either a pair of headphones or a small magnetic speaker. The power supply employs a type 80 tube operating as a full wave rectifier supplying 250 volt plate potential.

Each stage in the set is terminated in an ordinary wall socket, and the connection to the next stage is ordinarily made by means of a short double wire running to another socket adjacent to it to which is connected the input leads of the next stage. However, by using a longer wire it is possible to skip any stage by bridging over it. The set will operate with any stage except the detector missing, although its power is greatly decreased. Thus the purpose of each stage is impressed upon the student.

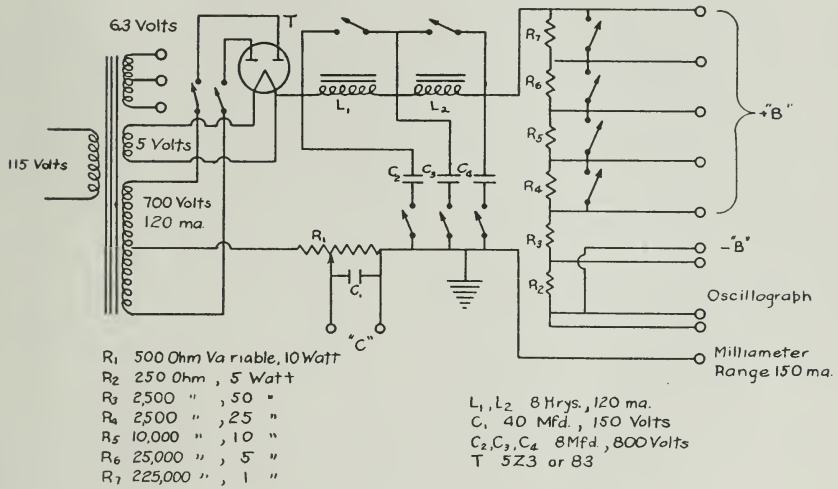
On the top of the mounting board and running the entire length of the set is an oscillogram giving the wave form of a typical signal for the stage immediately below. Thus the progress of the signal is graphically illustrated from antenna to loudspeaker. It is also possible to connect an oscilloscope at any stage and obtain the wave form of an actual signal. In this manner the effects of detection and amplification are readily shown.

The set was built at virtually no cost by Mr. John P. Karbler from discarded materials which inevitably collect in any laboratory. The mounting board is ⅜″ plywood, 6′ x 3′, painted white and permanently mounted to the wall. The set was built under the direction of Dr. Harvey B. Lemon. It is used both for the instruction of superior students in the Physical Science Survey course and for the students in the regular General Physics course. It has proved to be of invaluable assistance in demonstrating the basic principles of radio to beginning students.

A DEMONSTRATION POWER SUPPLY

O. L. Railsback

Eastern Illinois State Teachers College, Charleston, Illinois



In the teaching of an elementary course in Radio it frequently is desirable to show the action of the various parts which go into a standard power supply. The apparatus here described has been planned to make this possible without the necessity of re-wiring circuits each time a new observation is to be made. The circuit diagram shows the arrangement of parts and switches. It is "fool-proof" in the sense that no damage can be done to the unit with any combination of open or closed switches. With this unit the following observations can be made merely with the opening or closing of switches:

1. Half-wave rectification
2. Full-wave rectification
3. The separate effects of each component in the filter section
4. The effect on voltage of condenser or choke in-put
5. The effect of varying load on voltage out-put. Data for six or more points on a calibration curve for a given filter arrangement are available by opening and closing switches.

The effect of using a high vacuum or mercury tube can be shown by interchanging a 5Z3 and 83 type tube.

The unit can be used as a power supply in an amplifier or radio. "A", "B", and "C" voltages are available at binding posts, and the necessary auxiliary instruments are milliammeter, voltmeter, and oscillograph.

WHY NOT EXPRESS THE HORSEPOWER IN FOOT-POUNDALS?

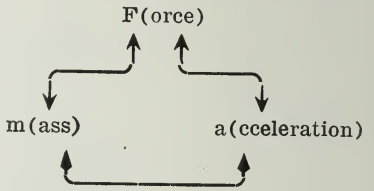
C. E. Ronneberg

Herzl City Junior College, Chicago, Illinois

The concepts of mass, acceleration, force, energy, and momentum are the very basis of mechanics, the foundation of all the physical sciences. In spite of the importance of these concepts, teachers in science and engineering must admit that we have a long way to go before we achieve uniformity in the handling of these concepts. The prejudices of workers in physical science in regard to the units used to measure mass, force, energy, and momentum are distressing to the beginning students who must decode the writings and usages of the many authors of physics and engineering texts. It is worthy of note that the students of physics in France, Germany and other European countries escape this confusion because they are familiar with only one system of units—the absolute c. g. s. system. In this country teachers and students must struggle along with both the gravitational and absolute system of units.

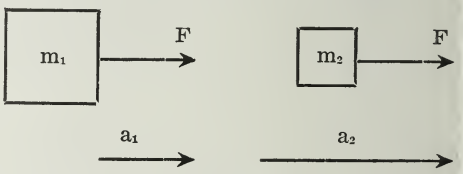
Many teachers of physics feel that the best way to handle the second law equation of Newton is to resort only to absolute units and the equation, $F = ma$. However, the concept of horsepower is so entrenched in the minds of the engineers and the public in general that they have despaired of entirely dispensing with gravitational units. Many teachers feel that it is necessary to teach the idea of pound of force because of its relation to the horsepower as 550 foot-pounds per second. They feel impelled to devise some system of handling $F = ma$ which will permit solution of problems in either gravitational or absolute units. Many teaching devices have been invented to accomplish this dual purpose.[1] One common method is to make use of two different sets of equations for force, energy, etc., one for use with absolute units, and one for gravitational units.

The concepts of force, mass, kinetic energy, and momentum in reality are not simple concepts. They are due to contributions by philosophical and mathematical thinkers of the caliber of Newton, Galileo, Descartes, Johannes Bernoulli, and Huygens. Ernest Mach[2] in 1888 pointed out that Newton's definitions of mass and force leave us in a logical circle:



These three concepts are all interrelated and physicists have adopted two different procedures to build up a system of units around them.

Procedure I. The relationship between *two different masses* is determined experimentally by the measurement of the *different accelerations* produced by the *same force* acting on the two masses.



This led to the relationship,

$$m_1/m_2 = a_2/a_1 \qquad \text{Equation 1}$$

Eventually the followers of this procedure arbitrarily selected a convenient reference mass, the gram or pound to measure the magnitude of any other mass in terms of this reference mass by the determination of the different accelerations imparted to the two masses by the *same force*, the masses and accelerations being inversely proportional to each other, i. e.,

$$m_2 = m_1(a_1/a_2) \text{ — } a_1/a_2 \text{ when } m_1 = \text{unity} \qquad \text{Equation 2}$$

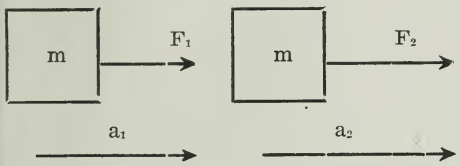
[1] Cf. Perkins, Science, October 14th, 1938; Beardsley, Science *89*, No. 2299, p. 58 (1939).
[2] Dampier, William, History of Science, Macmillan Co., New York, 1932, p. 170.

The accelerations of course are expressed in terms of length and time, as cm/sec² and ft/sec². In this experimental procedure the acting force remains constant. This is implicitly stated in the expression given in Equation 2 since

$m_1a_1 = m_2a_2 = a$ constant. Equation 3

This led to the common statement of the second law of motion, $F = ma$. In this procedure, force must be a derived unit dependent upon the units of mass, length and time. In this way our common absolute units of force, the dyne and poundal came into use.

Procedure II. In this procedure the relationship between *different forces* was determined experimentally by measuring the *different accelerations* imparted by *different forces* on the *same mass.* The accelerations are directly proportional to the applied forces, or



$F_1/F_2 = a_1/a_2$ Equation 4

This method requires the use of a standard force and corresponding acceleration which is usually the weight and acceleration due to the attraction of the earth for the given mass at place where the experimental work is carried out. The last expression is changed to

$F/Wt = a/g$ Equation 5

This is sometimes called the ratio form of the second law. This method requires the use of the concept of weight and this naturally led to the gravitational units of force. It should be noted that the concept of mass is not involved in Equation 5. Many physicists contend that Equation 5 in that form is the most fundamental equation in mechanics.[3]

Both procedures have been used which is responsible for the great confusion that exists in regard to the units of mass, force, and energy. "Difficulties . . . . . arise from the fact that two systems of measurement of force are actually in use alongside one another, thus producing the appearance of two fundamentally different definitions of force."[4] Unfortunately, the followers of Procedure II adopted the concept of pound of force. In order to get the notion of pound of force, it was necessary to use the pound of mass. To add to the confusion a new unit of mass was invented, the slug. In order to have the second law in the form $F = ma$ mathematically, Equation 5 is slightly altered,

$F = Wt(a/g) = W/g(a) = Ma$ Equation 6

When F is expressed in pounds of force and a in ft/sec², then the new unit of mass, the slug, is a derived unit and is defined as that mass in which a force of one pound will produce an acceleration of 1 ft/sec². In effect the followers of Procedure II in a round about manner go from our unit of mass, the pound, to the pound of force and back to the hypothetical unit of mass, the slug, in order to use the second law in the form, $F = Ma = Wt/g(a)$. In practice this results in the use of two sets of equations in mechanics as illustrated below:

Results of Procedure I

P. E. $= mgh$
K. E. $= \frac{1}{2}\ mv^2$
$F = mv^2/r$

Procedure II

P. E. $= mgh/g = mh$
K. E. $= \frac{1}{2}\ mv^2/g$
$F = mv^2/rg$, etc.

Often the followers of Procedure II do not actually stress the use of the term slug.

As stated before the reluctance of many teachers to discard the gravitational units of force is due to the use of the foot-pound in the horsepower unit. But it is still possible to retain the horsepower unit and express in absolute units as *foot-poundals per second.* For some reason this is not done by writers of physics and engineering texts. The legal definition of the pound in this country as stated by the Bureau of Standards is a mass equal to 453.5920 grams. The average value of g at sea level and 45 degrees latitude is 32.1740 ft/sec². Hence, the horsepower in absolute units will be,

$$P = W/t = F \times S/t = mgS/t = \frac{(550 \text{ lbs})\ (32.1740 \text{ ft/sec}^2)\ (1 \text{ ft})}{1 \text{ sec}}$$

$= 17696$ foot-poundals per second

For ordinary calculations, the horsepower can be expressed as 17,700 foot-

[3] Cf. Huntington, Science, *41*, 207-209 (1915).
[4] Bavink, The Natural Sciences, The Appleton-Century Co., New York, 1932.

poundals per second with an error of 0.02 per cent.

For problems involving the conversion of mechanical energy into heat, the mechanical equivalent of heat can likewise be expressed in foot-poundals per B. T. U.

1 Calorie = 4.184 joules
1 B. T. U. = 252 cal = 252 x 4.184 joules
= 2.50 x 10^4 foot-poundals

Expressing the horsepower and the mechanical equivalent of heat in absolute English units means that only one set of equations is needed to measure force, work, potential and kinetic energy, etc. The parallelism between the absolute metric and English units is quickly grasped by the beginning student in physics.

NORMAL DAILY TEMPERATURES FOR AURORA BY COMPARISON WITH CHICAGO

Clarence R. Smith

Aurora College, Aurora, Illinois

The normal daily temperatures at Aurora have been much desired as a matter of popular interest including use by the local newspaper which would like to report a comparison each day with the current mean. Since the use to be made of these normals is general rather than technical or scientific, it did not seem justifiable at this time to undertake the rather laborous Fourier series method or even one of the elaborate arithmetical smoothing methods which have sometimes been used.

The method here employed was suggested to the writer by Mr. C. F. Jespersen of the Chicago downtown station of the U. S. Weather Bureau. It consists of comparing the Aurora monthly normal temperatures with the Chicago monthly normals and applying this variation to the Chicago daily normals to obtain Aurora daily normals. The city of Aurora is located 36 miles from downtown Chicago, in a direction west and slightly south. The figures used for the Aurora monthly normals were those published in the 1940 year issue of *Climatological Data* and represent a record covering 61 years ending with 1940. The Chicago figures, both monthly and daily, were those appearing in the *Annual Meteorological Summary*, 1940, for Chicago, published by the U. S. Weather Bureau at that city. This record represents a period of 69 years.

The twelve departures of the Aurora from the Chicago monthly normals were plotted on calendar coordinate paper and a smooth curve drawn among the points. From this curve a departure was read off for each day of the year. These departures were then applied to the published Chicago daily normals to obtain Aurora daily normals as shown in the accompanying table. Certain values were adjusted slightly by interpolation to fit more consistently with the data just before and after. In no case was the adjustment more than 1 degree. In case of departure ending in .5 the choice of whether to use the next whole number higher or lower was determined by examining the adjacent data.

The summer maximum at Aurora is higher than that at Chicago while the minimum in winter is lower. Yearly curves for the two localities are quite similar in shape but the Aurora curve is in general ahead in phase by about 5 days. These and other phenomena which developed in making the comparisons, deserve farther study but are considered aside from the main objective of this paper. It is believed that the Aurora

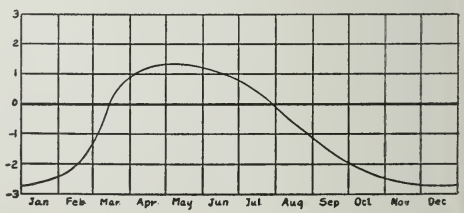


Fig. 1.—Departure of Aurora normal monthly mean temperatures from similar data for Chicago.

daily normals here formulated are of sufficient accuracy to be of practical value until such time as more elaborate methods might become necessary. Acknowledgment is made to Mr. Jespersen not only for suggesting the method, but for his kindly interest and his offer of library facilities. Mr. F. J. Thomas of the Chicago station also made suggestions which proved to be of much value.

AURORA DAILY NORMAL MEAN TEMPERATURES

Day	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
1	22	22	29	42	53	64	72	73	68	58	45	31
2	22	22	29	43	54	64	72	73	68	58	43	30
3	22	22	30	43	54	65	72	73	68	58	43	30
4	21	22	30	44	55	65	72	73	67	57	42	29
5	21	22	30	44	55	65	72	73	67	57	42	29
6	21	22	31	44	55	66	72	73	67	56	41	29
7	21	22	31	45	55	66	72	73	67	56	41	28
8	21	22	32	45	56	66	72	73	66	56	40	28
9	21	23	32	46	56	67	72	72	66	55	40	28
10	21	23	33	46	57	67	72	72	66	55	39	27
11	21	23	33	46	57	67	72	72	65	54	39	27
12	21	24	34	47	57	67	72	72	65	54	39	27
13	21	24	34	47	57	68	72	71	65	53	38	26
14	20	24	34	47	58	68	73	71	64	53	38	26
15	20	24	35	48	58	68	73	71	64	53	37	26
16	20	24	35	48	59	69	73	71	63	52	37	26
17	20	25	36	49	59	69	73	71	63	52	36	25
18	20	25	36	49	59	69	73	71	63	51	36	25
19	20	25	37	49	59	69	73	70	62	51	35	25
20	20	25	37	50	60	70	73	70	62	50	35	24
21	20	26	38	50	60	70	73	70	62	50	35	24
22	21	26	38	50	61	70	73	70	61	49	34	24
23	21	26	39	51	61	70	73	70	61	49	34	24
24	21	27	39	51	61	71	73	70	61	48	33	23
25	21	27	40	51	62	71	73	69	60	48	33	23
26	21	28	40	52	62	71	73	69	60	48	33	23
27	21	28	41	52	62	71	73	69	60	47	32	23
28	22	29	41	52	63	71	73	69	59	47	32	23
29	22	29	41	53	63	72	73	69	59	46	31	23
30	22	-------	42	53	63	72	73	69	59	46	31	22
31	22	-------	42	-------	64	-------	73	68	-------	45	-------	22

WAVE FORMS OF PHASE-SHIFTED SINE PULSES AND THEIR APPLICATIONS

J. T. Tykociner and L. R. Bloom

University of Illinois, Urbana, Illinois

In the course of development of an automatic recorder of spectral sensitivities of photoelectric cells, means were required for producing pairs of 60 cycle modulated light sources whose intensities could be sustained in definite phase relations. This led to a theoretical study of rectified phase-shifted sine waves. Enhanced by an urgent demand for a practical method of precise determination of small phase shifts this work has been further developed experimentally. The main theoretical and experimental results are given in the following brief report.

The task set for the theoretical investigation consisted of finding new wave forms characterized by sharply marked critical points whose coordinates would determine the phase shifts. Such new wave forms were derived by the superposition of two rectified phase-shifted sine waves.

Three distinct wave forms have thus been studied:

(1) Those obtained by the subtraction of two rectified phase-shifted sine waves.

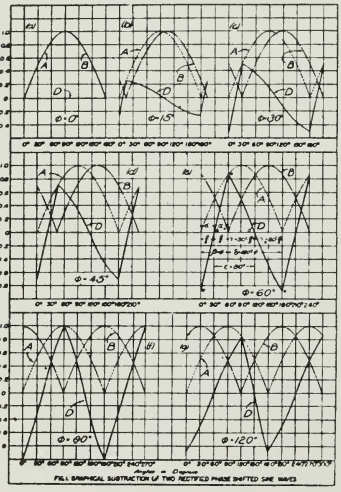


Fig. 1.—Graphical subtraction of two rectified phase-shifted sine waves.

(2) Those obtained by the addition of two rectified phase-shifted sine waves.

(3) Those obtained by a rectified phase-shifted sine wave added to or subtracted from a full sine wave.

Due to space limitation only the first type of wave form will be discussed here.

Fig. 1 represents graphically the subtraction of instantaneous values of two phase-shifted rectified waves, A and B, of equal amplitude and frequency. Each of the seven graphs shows the resultant wave shape $D = A - B$ for a particular phase shift ϕ, namely, $\phi = 0°$, 15°, 30°, 60°, 90°, and 120° respectively. The resultant curve D appears as an alternating wave of double the frequency of the original sine wave. The curve has sharp peaks marked a, c, and e. It crosses the X-axis at the points b and d. Interesting from the point of view of practical application is the property which makes the amplitude of the curve D proportional to the sine of the phase angle ϕ. A further property is that for $D = 0$, $\alpha_{b,d} = K\pi/2 + \phi/2$, where $K = 0, 1, 2, \ldots$ and that the value of the abscissa for the maximum is $X_c = K\pi + \phi$ and for the minimum, $X_{a,e} = K\pi$. With increasing phase shifts the wave form develops gradually from an unsymmetrical shape with a small amplitude into a symmetrical triangular form of maximal amplitude at $\phi = 90°$. Similar studies of the two other types of wave forms mentioned under (2) and (3) reveal other characteristics also depending on the phase angle.

In order to examine the possibility of producing such wave forms in electrical circuits, the oscillographic method was applied in connection with mixing circuits for combining the two rectified phase-shifted sine waves.

Fig. 2 is an example of a series of oscillograms thus obtained for $\phi = 0°$, 15°, 30°, 45°, 60°, and 90° respectively. The left column shows the component rectified

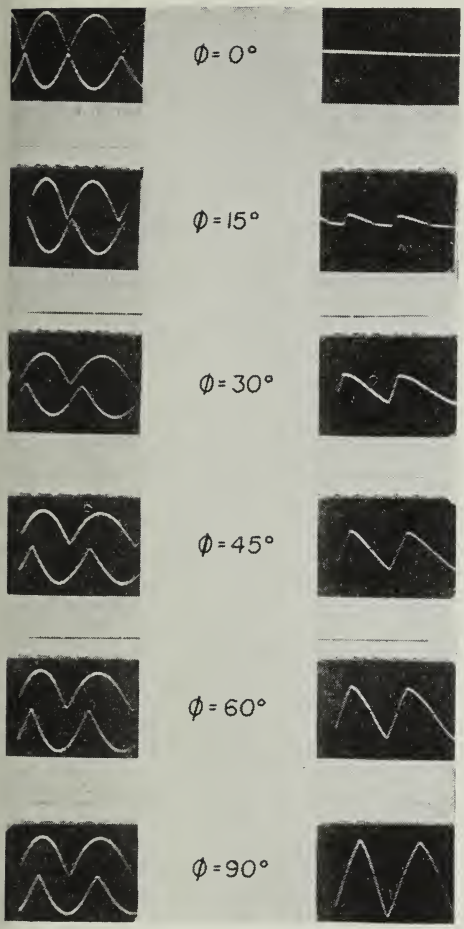


Fig. 2.—Oscillograms showing subtraction of two rectified phase-shifted sine waves.

sine waves each taken by a separate exposure while the second column of oscillograms shows the resultant forms changing as the phase is varied step by step. These correspond closely to the curves theoretically predicted.

In order to produce any required definite combination of currents it was necessary to develop accurate means for adjusting phase angles of the component currents. The oscillograms shown in Fig. 2 were obtained at 60 cycles per second by a known method of addition of electrical vectors in quadrature relation.

For audible frequencies from f = 500 cycles to f = 10,000 cycles per second a more accurate method of obtaining phase-shifted currents was developed.

As shown in Fig. 3, in room I were placed the oscillator O, whose frequency could be varied from 20 to 20,000 cycles per second. The oscillator was coupled to a transmitter T. For frequencies not exceeding 2,000 cycles this transmitter T, consisted of a high impedence earphone of the Baldwin type. For higher frequencies it was replaced by a high fidelity driving unit of a dynamic speaker whose voice coil impedance was 16 ohms and whose audio spectrum extended from 30 to 10,000 cycles. At a distance d_1 and d_2 of approximately two wave lengths were placed two high impedance headphones P_1 and P_2, identical in their characteristics. One of the headphones, P_2, was fixed in position. The other, P_1, was mounted on a stand and could be shifted between guides by means of a worm-gear G. By turning a crank K, the distance d_1 could be varied and set to any desired position with an accuracy of $\pm$ 0.2 mm. For each given phase angle ϕ, the distance $d = d_1 - d_2 = \phi v/\pi f$ could be calculated from the sound velocity v and frequency f and then adjusted accordingly.

In room II were placed two sets of measuring equipment. Each set consisted of a voltage amplifier (V_a or V_b), a matching transformer (W_a or W_b), a full-wave rectifier (Y_a or Y_b) and a coupling circuit (Z_a or Z_b).

The outputs, a and b, of the receiver headphones P_1 and P_2 were fed through shielded concentric cables into the re-

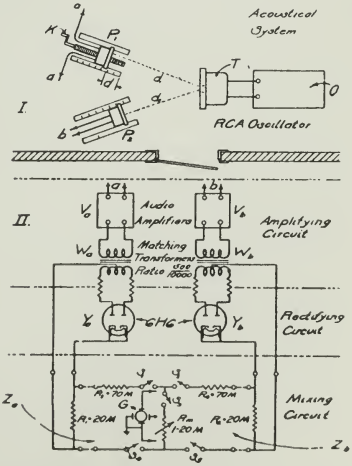


Fig. 3.—The acoustic phase-shifting apparatus.

spective amplifiers V_a and V_b. An oscillograph G was used as an indicating instrument to observe the resultant wave forms.

For frequencies from 10,000 to 100,000 cycles the method of adjusting circuit constants was used for producing phase shifts. Thus, the entire frequency spectrum over the range from 30 to 100,000 cycles was found adaptable in connection with the described wave forms.

The applications of the new wave forms are manifold. By direct use of an oscilloscope which records the wave forms on a screen, it is possible to measure the coordinates of the critical points of the resultant wave forms and thereby determine phase differences. However, more refined methods of utilizing the characteristics of the new forms are being developed. Of other applications which are in the course of development, the following may be mentioned as examples: time axis sweep circuits for oscillograph and television tubes, square wave generators, and harmonic oscillators.

A complete report concerning the mathematical and experimental investigation will be published in a Bulletin of the University of Illinois' Engineering Experiment Station.

Papers in Psychology and Education

From the Report of the Section Chairman

Six papers were contained in the program at the Urbana meeting, 3 of which are herewith printed. The others were:

DeYoung, Chris A., Illinois State Normal University, Normal.—*Financing public education in Illinois.*

Hibler, Frances W., Illinois State Normal University, Normal.—*The problem of student morale during war.*

Witty, Paul A., Northwestern University, Evanston.—*Mental hygiene effects of war upon children.*

Twenty attended the session.

L. A. Pennington, Physiological Psychology Laboratory, University of Illinois, was elected chairman for the Jacksonville meeting in 1943.

(Signed) J. H. Hughes, *Chairman*

WARFARE BETWEEN HUMAN NATURE FICTIONS

Coleman R. Griffith

University of Illinois, Urbana, Illinois

It is obvious beyond all question that this war is being fought between armies, navies, flying forts, and radios which are owned by, and serve the interests of, the several nations. These nations, or the people who lead them, hate each other and are bent on the destruction of their enemies. It is not quite so obvious, but nonetheless true, that a struggle is being waged between patterns of belief, forms of government, systems of finance, claims to priority in access to raw materials, means of control over ocean lanes of traffic, and rights to sell goods in preferred markets. As an integral part of these factors, there are the roots of evil intentions which are said to lie in balances of power, race hatreds, old debts to be paid, and the desire to remedy ancient wrongs. Still less obvious are the brutal qualities that are commonly attributed to man's original nature, — his lusts, instincts, and other echoes of the fact that he stems from the beasts of the field. This might be called, then, a war of machines, a financial war, a political war, a war of ideologies, a war of empires, and a struggle for survival, but in none of these manners of speech has the final and irreducible nature of the conflict been indicated. In the last analysis, it is a psychological war. Stripped of all the trimmings of men and machines, or of policies and practices, this is a war of man against himself. It is civil war in the body psychologic. It is a war between fictions about the nature of human nature, that is, a war between partial views of the traits of men and of what they need in order to live.

Since all of us are men who normally pursue a double path toward self-knowledge, that is, a path among the immediacies of self-inspection, and a path among inter-behavioral contacts with our own kind, any appeal to the notion that we are the witnesses at a civil war among human nature fictions stands forth, at first sight, almost as a peculiar kind of nonsense. If there is anything in the whole universe that should be known with precision, and in the fullness of its being, it is man's own nature. Moreover, it is said to be one of the most patent facts of history that human nature is the same the whole world over; and yet, instead of a view of himself in the wholeness of his character, one must still insist that death is the price being paid for a wild array of partial views and of absurd abstractions which are battling one another to the bitter end. Some of them have stood out to the exclusion of all of the others, and some of them have been united with others so as to form curious caricatures of the truth.[1] There have been biological, rational, spiritual, economic, political, liberal, nomadic, western, oriental, romantic, pragmatic, mystical, humane and military or power men, to say nothing of the man of the golden mean. These terms have not been used to name the several facets of the whole of the psychological creature. They have been taken as real names for views that have been held of man's essential constitution as displayed in what he has done, what he wants, what he will strive for, and for which he will give up his life. Some of them are names for the kinds of men who are now grasping each other's throats or blasting out each other's brains from the skies.

There is, then, at the very center of man's universe a strange paradox. He ought, since he is always his own subject and object, fully to know himself in the completeness of his nature, and yet the actual record shows scarcely an instance when he has scored a notable success in synoptic comprehension. So grave a failure must be explained and, fortunately, the answer is not far away, for man has at last become a problem to himself, and this is the beginning of wisdom. It is first to be observed that men

[1] Each of them, of course, will hold that it reveals the truth, all the others being defections from the obvious and the essential. See, for example, Maritain, J. Christian humanism. *Fortune,* 1942, *25,* 106 ff.

must, if the immense variety of partial views which crowd the record are to make any sense at all, be extremely versatile in their resources for adjustment to life situations. The plain fact is that they do have capacities for meeting their environments which can be channeled into action in an amazing variety of ways. In the second place, it is wholly clear that life situations vary over an immense area from deserts to lavish riches, from battle, mating and feeding to dialogue, friendship and aesthetic pleasure, from being ruled to the role of ruler, from working and producing to selling and saving, and from manual labor to deep concern about angles, sizes, words, verbal propositions and final principles. When pieced together, these two kinds of facts point to a single conclusion. At a time and a place within a given culture, and for a given purpose, men are able to mobilize their rich resources for adjustment in precisely those patterns which appear to be adequate to the conditions which prevail.

This conclusion, however, marks only the first step in the creation of human nature fictions. When a particular set of life situations is intensely demanding, the whole scope of human nature will appear to be expressed in exactly those habits, skills, attitudes, and thoughts that have been designed to meet the demands. But it is at this point that the next step in the creation of a fiction is normally taken. In proportion as the designs for action meet with success, they will be used to prescribe the rules for response to all kinds of situations, in all kinds of cultures, even though the initial conditions which gave rise to them have already passed away. But success alone is not enough. The traits aroused by one life situation in its own climate of opinion, when utterly demanded by that situation, are often abstracted from their functional dependency on time and place and converted into the intrinsic rights, duties, essences, or powers of the adjusting individual. In short, they appear to express the laws of the inner nature of man, and they are made prescriptive, therefore, not only for the same but for all other kinds of situations. They become definitions of what it means to be a human being. Moreover, — and this is the final step in the creation of fictions,—the adjustive habits required by local conditions of time and place are quickly transformed into rules, codes of law, customs, institutions and political or other social arrangements which appear to be right because they manifestly embody the wants, the best thoughts, and the hereditary qualities of the men who have created them.

A single example will suffice. With the advent of the machine at the outset of the Industrial Revolution, the ways of men with respect to machines, to raw materials, to goods produced, to sales, and to bank accounts passed through the mighty transformation that marked the end of feudalism. Moreover, their manners of dealing with one another in the market place and in the forum took on a flavor which set them off from the customs that had prevailed in feudal times. Men who owned land gave way to men who owned goods or banks, and in proportion as almost any one could share in the new kinds of ownership, men became individualists endowed with the kinds of rights that individuals ought to possess.[2] From an earlier period, these new kinds of men drew upon the fiction of rational men as it had been perfected by those who had learned how they ought to behave if they were to deal adequately with geometry, mathematics, or with the meanings of words when they are used to compose a syllogism. The result was, first, an economic sort of man ruled by reason in behalf of enlightened self-interest, and, second, a whole array of political, commercial, international and military arrangements, intended to bring in a constant flow of raw materials and send out a constant flow of goods to be sold for a profit. This economic man was a liberal, an individualist, or a capitalist whose habits, emotions, and points of view, instead of being relative to the kind of world in which living had to be accomplished, appeared to stem from his genes and be expressive of his inalienable rights. His government, his treaties, his wars, his peace pacts, his schemes for a balance of power, and his attitudes toward natives in the far corners of the earth, accordingly, were merely public and institutional expressions of what he conceived to be the

[2] Cf. Laski, H. The Rise of European Liberalism. London: G. Allen and Unwin, 1936.

intrinsic human nature granted to him by his Creator.[3]

This is, of course, an extremely sketchy view of a complex process. This is not the place, however, to fill in the details, whether for economic or any other kind of man, and neither is it the place to find out how various types of men fare when they go to war in order to protect what they manifestly feel to be the inner essence of their own natures. We must not even attempt to trace the way in which economic, religious, democratic, totalitarian, communistic and emotional men, with all their associated practices and arrangements, are caught in the present tangle of world-wide conflict.[4] The existence of human nature fictions, however, raises one question which is pertinent to this program. Given the conditions which produce a varied assortment of human nature fictions and which place them in bitter conflict, what is it that preserves them and sheds an aura of finality over them? The answer is: Education. Education is one of the very first of the arrangements set up by groups of men in order to develop youth in accordance with the fundamental nature of human nature. In short, educational systems also go to war. In fact, they are employed long before the advent of overt conflict in order to prepare men more heroically to defend or to die for the values and natures ascribed to them by the fictions they have created. Moreover, it is education upon which is placed the burden of instruction regarding civilized habits, customs, institutions, practices and loyalties which, because they appear to be grounded in human nature, constitute exactly the substance of the various nations which spring at one another's throats. Stated in another way, if wars are fought between human nature fictions at the level of the political, social and economic arrangements which embody these fictions, then education is the primary agent by which the truth and the authority, both of the fictions and of the arrangements, can be nurtured to the point of complete conviction and utter devotion.

If, however, education can go to war in this fashion, it ought also to be subject to mobilization in the interests of peace. What is needed is not an education which will change human nature or a mode of training which will eliminate brutal instincts, but an education which will strive toward, because it is based on, the whole of the psychological person in the full array of his adaptive talents.[5] For some situations, and when to the manner trained, men should be rational, but they might also be romantically and economically as well as religiously and politically democratic, and scientific in method as well as emotional and worshipful in their rights and duties. In short, then, these several words could not be used as the names of kinds of men in a culture whose education was expressly designed to develop the whole of the psychological person. Moreover, they could not be the names of the human nature forces, whether they are called instincts, innate ideas, or the first principles of being, which guarantee finality to political, economic and social arrangements. By contrast, they would name degrees of excellence, now in this facet and now in that facet, of races of men in accordance with the duties they must perform and the relations they must establish with respect to others of their own kind in the common business of removing occasions for civil war in the body psychologic.

It should be obvious that the road away from revolution lies in this direction, for men who intend fully to realize the whole of their natures will not tolerate institutions, standards and practices which are a violation of what they need and must secure if they are to avoid ceaseless conflict. They will, instead, create institutions which are compatible with the kinds of human nature their educative process has directed them to achieve. If, for example, it is affirmed that a form of government, or a system of banking, is finally and absolutely true because it is based on human nature, then schools ought to teach that form of government and its financial arrangements. On the other hand, however, if the human nature which is said to underlie a form of government can be shown to be a fiction produced by the chances of time and place, and wholly relative to a given culture, then education, instead of becoming a form of propaganda in order to pre-

[3] Cf. Browne, L. Something Went Wrong. New York: The Macmillan Co., 1942.
[4] Cf. Drucker, P. F. The End of Economic Man. New York: John Day Co., 1939.
[5] Cf. Tolman, E. C. Psychological man. *J. Soc. Psychol.*, 1941, *13*, 205-218.

serve the fiction, ought to stand forth as an agent for the training of men who will gradually and thoughtfully amend their government and all other institutions so as to make them fully expressive of the whole of their psychological beings.

The crucial test of this assertion is said to lie in the relations that obtain between human nature and democracy. Democracy, of course, has been defined in a great many ways, but none of them emphasizes so many facts as the argument that plans for self-government name a direction of becoming rather than a state of being. Likewise, human nature can be defined in a great many different ways, but none strikes quite so close to the spread of man's abilities as the statement that the scientific method, that is, the operating intellect which uses goals as means to further ends, demands more of the whole person than any other possible statement about him. Human nature and democracy, then, became twin-like terms, for adjusting men who exemplify the scientific method are the premise of, and the necessary condition for, the coming-to-be of democracy. The alternative is to use the processes of education in the interests of conformity, that is, in the interests of maintaining an existing fiction about human nature and about all the social arrangements contingent thereon. In this case, education becomes an extremely powerful agent for the promotion of wars without end, for its natural product is a multiple personality whose members are always in conflict, either directly or by way of social structures. On the contrary, however, education can be used for a peculiarly human and democratic purpose, namely, to direct growth toward the actualization of all the powers of adjustment of the whole of the psychological person. In this case, educated men become, first, the necessary correctives of the formal agencies by which their lives will be regulated, and second, the natural mode of approach to a time when wars need no longer be waged because men no longer fashion themselves into their own worst enemies.

HANDWRITING AS A FACTOR IN CREDIT ANALYSIS

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Credit is the name given to that business operation by which delivery of money or merchandise or other consideration is made on the promise of future payment. Credit is based on confidence; confidence in a man's resources and ability to pay, in his character and integrity; confidence in the stability of the locality in which he conducts his business; confidence in the government under which he lives. Credit-making is an estimate or opinion of future commercial conditions and of the ability and intention of men to carry out a contract. So important has this aspect of American business become, that up to the present emergency roughly one-third of American merchandising was done on credit.

Credit extension has long been granted on what is largely a mechanical and statistical approach, based chiefly upon economic factors. One widely used method seeks to determine the credit character of a customer from the information furnished by him. The applicant is asked to answer certain questions with respect to race, marital status, length and type of employment, age, income, other credit affiliations, references, etc.

While tangible assets may be an important basis for the extension of credit, yet it can be stated absolutely—and it is an agreeable evidence of the large part which the human element, man himself, plays in the more or less sordid operations of business—that the rock-bottom foundation upon which the whole system of credit is based is character. Those characteristics of the applicant himself most significant to the credit man are rightfully identical with the most essential elements of success in any man: honesty, good habits, ability, industry, economy, and care in the conduct of his business. Of these assets none can be levied upon by law, but just as a man cannot attain success without them, so a credit man cannot safely give credit to an applicant lacking them. In fact, if a credit man could be absolutely sure of an applicant's honesty, most other considerations could safely be eliminated. Not that honest men never fail, for they often lack ability and other essentials, but between the man with large resources and doubtful honesty, and the honest but financially weak man, the latter is the better credit risk.

Undoubtedly in credit extension there are at least two aspects: an economic one (the ability to pay) and one largely psychological (the intent to pay). It appears most likely that our credit concerns are better equipped to deal with the economic aspect than with the psychological aspect. This paper will report the research which has convinced one Chicago concern, which does a large credit business, that handwriting can be an important factor to be considered in the extension of credit.

The prevailing attitude toward handwriting analysis among American psychologists is one of scepticism and distrust. Along with phrenology, palmistry, and astrology it is contemptuously dismissed or deplored as charlatanism. The commercial abuses of graphology seem to have disqualified this type of analysis for impartial experimental study. Consequently very few American psychologists have studied its methods or claims seriously; in their unfavorable criticisms they seldom refer to more than one or two inconclusive experiments. The typical American attitude has been expressed by John B. Watson. Depending as many of the critics of graphology do, upon a single experiment of Hull and Montgomery, he concludes that all claims for graphology are "a tissue of exaggerations" which "will not bear critical experimental testing". Since this famous experiment has only remote relation to most of the claims of graphologists and practically none to their methods of work, it is a meager and insecure foundation for such a sweeping opinion. Watson wrote twenty

years ago, yet this attitude toward graphology still prevails.

Briefly, it may be said that American psychology and science regard handwriting as unrelated to the deep-lying central factors of personality, and as a product essentially of peripheral manual movement. In addition they consider it to be influenced greatly by external conditions of instruction and example. European psychologists on the other hand see in handwriting the essence of expression, reflecting many, if not all, of the inner constituents of personality.

In sharp contrast to the scepticism and neglect in this country we find an alert and sympathetic interest in Europe. Many reputable psychologists on the continent are following the topic and experimenting in the field of handwriting.

It was one of these European psychologists, Dr. Walter Marseille, who initiated the research reported in this paper. Dr. Marseille, in addition to completing his doctoral dissertation analyzing and criticising the methodology of the various European schools of graphology in 1926, had many years experience as a private consultant. He saw the possibilities of handwriting analysis as a factor in credit extension, and a large Chicago merchandising company, which we shall call the X-company, became interested. The X-company is a progressive company with special credit problems. Over the past ten years its research department has developed a rather extensive and complicated point system which it applied to individual applications for credit. Its management, however, anxious to cut down credit losses, have long been on the alert to improve their credit rating system and invited Dr. Marseille to conduct research to demonstrate the validity of analyzing the handwriting of the applicant before extending him credit.

It took him two years to integrate the experience with the American handwriting with its own national character and its peculiar conditioning. In the United States rather uniform conditions of instruction and example, such as the Palmer Method, have resulted in a certain amount of what might be called "conventionalized handwriting". The European work was mainly with handwriting of individuals on a much higher economic and cultural level than the Chicago firm's customer. Dr. Marseille, together with Prof. Paul Zagersfeld, has done special research on this very question of educational level. These results, based on Senatorial mail, were published in part in "Public Opinion Quarterly", Fall 1941.

But after acquainting himself with the handwriting level of the typical customer of company X, Dr. Marseille was given two tests devised by the company.

The first test was taken in New York. Two hundred order blanks were sent to him. Half of these orders were from customers who have proved themselves to be good credit risks; experience had shown that the other half should not have been given credit. Dr. Marseille was asked to separate the good from the bad credit risks after analyzing the handwriting on the order blanks. He did this with an accuracy decidedly better than their point system based on social and economic factors. The X-company was so impressed that they invited him to come to Chicago and carry out further research and take a second test. The second test included six hundred cases and the results were just as impressive. Dr. Marseille was able to demonstrate that credit losses were due not so much to dishonesty on the part of the applicant as to lack of adjustment, instability, and lack of integration. Furthermore, the characteristics were apparently revealed in the handwriting of the applicant.

The X-company was convinced that here was a method of analyzing credit risks that had great potentialities. But was this ability subject to training? Could it be applied to mass production? This was very important, since the X-company had, depending on the season, from 2,000 to 6,000 applicants for credit daily.

Dr. Marseille was given the task of selecting and training in his methods five young men and women. None of these trainees had any previous handwriting training or made any claim to intuitive gifts in this field. After twenty-five training sessions of three hours each for subjects 1, 2, and 3, and fifteen sessions of three hours each for subjects 4 and 5, all were given a test. The test material consisted of 500 order blanks, half of which were those of good credit risks and half were those of bad credit risks. The testees were asked to select roughly twenty percent of the cases which were called the extremes. These

TABLE I

Subject	Cases Rated	Cases Correct	% Correct	Extremes Rated	Extremes Correct	% Correct
1	356	250	70	106	87	83
2	363	238	66	100	72	72
3	373	220	59	100	71	71
4	375	228	61	100	69	69
5	322	197	61	100	70	70

were the cases which the testee felt most sure of being good or bad. In addition the testee could select as many other cases which he felt sure were good or bad as he wished. The criterion of whether a case was good or bad was of course the X-company's experience with it. If a customer had paid he was good, if he had not paid he was bad. The results of the test have been summarized in Table I.

The X-company felt that subjects 1 and 2 had performed satisfactorily on the test and they were permitted to carry on some private research which was designed to acquaint them with the operations and problems of the company and to see in what actual operational area their services could best be used. It was decided that subjects 4 and 5, who had had less training, should be given more training and a second test. Subject 3's performance was deemed unsatisfactory and he was eliminated from further consideration. It is interesting to note, however, that his results were on the positive side and definitely above chance.

Subjects four and five and a new trainee, subject six, who had previous training in Europe, were given twenty additional training sessions by Dr. Marseille and a second test. The results of this second test are summarized in Table II.

The X-company was satisfied with the performance of these three subjects and had them follow the same pattern of further training as subjects one and two. At the present time the handwriting analysis is definitely a part of the credit extension policy of the company. Credit applications are being examined by the handwriting analysis who accept certain applicants, reject others, and refer a third group of applicants to the regular credit extension programme.

It is impossible to discuss the method of handwriting analysis in the short time at my disposal. However, it should be emphasized that the method does not consist of looking for certain definite signs of dishonesty in a handwriting. Rather it is an evaluation of an individual's writing style as a whole. The Chicago firm is concerned primarily with negative aspects which are: lack of integration of the handwriting style, discrepancies in the handwriting style, and evasiveness of the style.

TABLE II

Subject	Cases Rated	Cases Correct	% Correct	Extremes Rated	Extremes Correct	% Correct
4	329	221	67	92	72	78
5	311	206	66	95	69	73
6	338	224	66	85	62	72

WHAT CAN THE ELEMENTARY SCHOOL DO TO PREPARE FOR WINNING THE PEACE?

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The last forty years have constituted a period of very rapid change in public school education. This statement is true of all features of the school system, including school buildings, professional training of teachers, compulsory attendance age and the like. In no department of education has it been more true than in the field of the curriculum. From a curriculum composed largely of dead, inert, static factual material, the schools have moved toward subject matter which is alive, changing and within the realm of children's interests and comprehension. Dead wood has been cut away and rich and stimulating new material has been added.

This change has been particularly noteworthy in the field of the social studies. In this section of the school curriculum there has been an increasing tendency to introduce problems of contemporary life and of national and international thought. Leading educational theorists have been largely responsible for this movement for they have insisted in their speaking and writing that the schools should introduce contemporary problems into their curricula.

On the whole this tendency has been a thoroughly desirable and healthy one. There is one aspect of it, however, that has been unfortunate. Theorists have used the expression "the school" in an entirely undiscriminating manner, as though the children of our schools were homogeneous in their maturity and power to grasp ideas or to deal with data. The absurdity of this assumption is obvious as soon as it is stated, but it has apparently not been recognized by many leaders and teachers in the elementary school. Urged on by the unanalytic pleadings of educational theorists, these practitioners have often introduced into the curriculum of the elementary school problems of economic, social and political import, the solutions of which require a capacity to grasp abstruse ideas or to manipulate complicated data which is far beyond the abilities of common school children. One often suspects that such ability may even be far beyond that of the average teacher!

At first thought, one might well conclude that the problem of winning the peace after this war is over is one of those complicated problems, the introduction of no element of which into the elementary school can be defended. It is, of course, obvious that such a topic as economic international relations after the war would be far too difficult for a child in the elementary school. But it is the belief of the writer that in a democracy there are three elements in the solution of most problems, and that with respect to the question of winning the peace, two of these elements can be presented to elementary school children.

The three elements are: first, the emotional background upon which a majority of our citizens must agree if they are to accept the solutions offered by their experts and representatives at the peace table; second, the mass of factual data which will constitute the basis for developing the peace terms; third, the actual solution of the world's peace problems as worked out in the final treaty.

As an illustration of these three elements consider the problem of how to satisfy the needs of all nations for the world's basic raw materials. This problem will have to be dealt with if a permanent peace is to be hoped for; indeed it was recognized as of first importance when Roosevelt and Churchill included it in the Atlantic Charter. In this document, "to further the enjoyment of all states, great or small, victor or vanquished, of access, on equal terms, to the trade and raw materials of the world" was stated as a war aim of the United Nations.

It seems obvious that if this provision of the Charter is to be fulfilled it will mean that nations will have to give up,

in some measure at least, their sovereign control of the raw materials within their boundaries. This will be a difficult thing for many Americans to accept; it will constitute a radical change in that emotional background in the light of which they have considered all relationships with foreign countries. The first element in the solution of the raw materials question is, therefore, the emotional framework within which the details of the peace treaty will be enclosed.

The second element is the factual one; where are raw materials found, how far have the different nations developed them, how far can they be developed, where are they located with respect to strategic transportation routes and present centers of industrial production. Many of these facts are very simple and can be easily understood and learned by children.

The third element is enormously complicated; it consists of the actual treaty provisions by which the intent of the Atlantic Charter statement is to be implemented. To determine these provisions will require the best brains of the United Nations and the consideration of extremely intricate data with reference to production, consumption, transportation, money values and the like.

The above analysis clarifies the answer to the problem of this paper, namely, what can the elementary school do to prepare for winning the peace? It is our manifest first duty in this section of our school system to go to work on the emotional background of our children. In the opinion of the writer, the previous efforts in this field have been distinctly harmful rather than helpful. They have been calculated to produce in our children a strongly nationalistic, if not actually jingoistic attitude. Our nation has been held up as the strongest in the world, with the best government and the highest standard of living existing anywhere. There is no objection to this, provided there is associated with it not the smug self-satisfaction which has been too characteristic of our national point of view in the past, but rather a sense of the international responsibilities which our fortunate position inevitably lays upon us.

It is the opinion of the writer that the provisions of the Atlantic Charter should be discussed frequently in elementary school classrooms, both incidentally in connection with classes in the social studies, and definitely in current events periods. With a study of these provisions should be coupled frequent considerations of the necessity of a democratic association of free peoples to put them into effect. Thus, children will grow up with certain emotional mind-sets which will make easy the acceptance of some points of view which are now difficult for the American people but which are essential if we are to have an enduring peace.

It may be argued that it is not necessary to expose little children to this sort of subject-matter. The answer to this contention is two-fold. First, if as it seems likely, it takes the world as long to win the peace after this war as it took it to lose the peace after the first world war, then children in our elementary schools will have become voters long before the peace is won. Second, emotional attitudes are acquired easily by younger children, and such attitudes are surprisingly permanent, coloring their thinking for many years to come.

It is obvious that our elementary schools have for a long time dealt with some aspects of the second element in solving the problem of winning the peace, namely the factual element. But here, too, the instruction needs to be changed. Geography has been losing its place in our common schools in the last few years; this movement needs to be reversed and a greater emphasis than ever before should be given to geographic education. Too frequently in the past, however, the study of geography has consisted in the enforced memorization of a vast number of unrelated facts about the various countries of the world. The geography of the future should have two main emphases.

First, it should stress the pattern of interrelationships between man and his natural environment. This point of view has been expressed many times in the last forty years, but it is still too inadequately followed in our schools which are still teaching locations, products and industries as unrelated data instead of as factors in understanding the varying ways in which man responds to his natural environment.

Second, the geography of the future must place far more stress on world relationships. We need to emphasize such

things as the world distribution of races; of such basic commodities as oil, rubber, coal, tin, iron and foodstuffs; and of transportation and supply routes. Only as we teach such types of subject matter can we hope for a group of future citizens who will understand what the terms of the peace treaty are all about.

In a democracy, it is not the peace plenipotentiaries nor the President who make the peace; in the last analysis it is the people who do it. It is, moreover, the sentiments and will of the people, as expressed through their representatives, which modify and readjust the terms of peace as time goes on after the acceptance of the actual treaty. For the early stages of the development of an intelligent electorate who are capable of grappling with these problems the elementary teacher has a heavy and vital responsibility.

Papers in Social Science

From the Report of the Section Chairman

Eight papers were contained in the program at the Urbana meeting, in addition to one given at the luncheon meeting by Florian Znaniecki, *The Social Scientist in Time of Crisis.* Six are herewith printed. Two others, presented in the same symposium, *The Fate of the Family,* were given by Ernest R. Mowrer, Northwestern University, Evanston, and Ruth Shonle Cavan, Rockford.

V. Dake Jolley, Wheaton College, Wheaton, was elected chairman of the Jacksonville meeting in 1943.

(Signed) C. W. Schroeder, *Chairman*

THE FATE OF THE FAMILY

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One way to forecast the fate of the family is to observe trends in the past and at present and to project them into the future.

What are the chief changes affecting the American family in the perspective of time?

First of all, if we contrast the colonial with the modern American family, it is apparent that the family has lost, or is still losing, its historic functions. The family as a unit of production for the market is gone except in rural districts. Many home activities of economic significance as canning vegetables and fruits, baking bread, laundering, making clothes and cleaning and dying them are vanishing from the family. Recreation has departed in large measure from the home, the only counter gain being the radio which paradoxically brings the entire outer world into the home. The education of the child is taken care of by the day nursery, the kindergarten and the school. Health and protective functions have been assumed in ever increasing degree by the state. Even religious practices like family prayers and grace before meals are on the decline. There can be no doubt that the family has lost so many of its functions that some ask what is left of sufficient significance to justify its continued existence.

The second great change is that young married couples are increasingly separated from the in-laws, in space and of more importance in spirit. Less and less each decade do husband and wife after marriage seek guidance from their parents. No longer is the larger kinship group an indispensable factor in regulating and guiding the small family unit.

A third big change, in part related to the preceding two, is the growing emancipation of the family from community controls and from the mores.

Many observers see in the superficial manifestation of this shift such as the smaller family and the increasing divorce rate evidence of family instability and perhaps its eventual disintegration. Sorokin like Le Play before him bewails the decline of the stable family and the rise of the unstable family.

Other sociologists and I count myself in that number welcome this change although granting the conflicts and losses incidental to a transition period because of its promise for a higher type of family in the future.

This break of the family with tradition is all-important because it means that each family is now on its own to realize in its own way its potentialities for development. Family stability based on the mores was valuable in a static society but in a dynamic society it can prevent the family from making necessary adjustment to new conditions and so stifle the freedom of family members for self-expression. The modern family face-to-face with a changing situation finds adaptability to be a more important characteristic than integration which we have all tended to value higher perhaps than is warranted by the facts.

This point, however, has recently been documented by a restudy of the original case-records upon which Robert Cooley Angell based his findings in his book, "The Family Encounters the Depression." He had indeed found that the adaptability as well as the integration of the family was important for its success in meeting the impact of the depression. The restudy of cases by the use of a rating scale and statistical methods shows that the adaptability of the family is much more important than integration in meeting a crisis such as the depression. In fact, when the factor of adaptability is held constant integration shows only a zero correlation with success in meeting the depression. This finding does not mean that integration played no part in adjustment to the depression. But it does indicate that only those elements in integration which made for adaptability aided the family in meeting this crisis.

It follows, in all probability, that the adaptability of the family and its mem-

bers in meeting changing situations provides the key to the future of the family.

That is why no tears should be shed over the loss of the historic functions of the family. They are a case of good riddance of old rubbish. Their disappearance allows the family to concentrate upon its essential functions, namely, affection-giving, the bearing and rearing of children and their informal education which can be and often is far superior to the education of the best schools.

The emancipation of the family from the in-laws and the mores frees it to substitute science for custom in the shaping of marriage and of family relations.

Already in one large area of family behavior tradition is in the discard and science is supreme. Children are now being reared by intelligent parents not as they were brought up by their parents but according to the advice of the pediatrician, the psychologist and the psychiatrist. The more intelligent the parent, however, the more he takes the advice of the specialist with a grain or more of common sense. The significance of this change cannot be over-emphasized. It means a revolution in our thinking and our way of life.

Signs are multiplying that this reliance on science first evidenced in child rearing is spreading rapidly to other areas of family behavior. Courses on education for marriage and family living are now being given in colleges and universities, in high schools and in programs of adult education. Most significant in its implications for the future is the mounting demand of college students for courses in preparation for marriage. Marital counseling services are being set up to give information and advice to couples before and after marriage. Young people are eager to obtain the latest findings of scientific research which may be of assistance to them in marriage and family relations.

Those who see the golden age of the family in the past and would seek to return to the large patriarchal family or some substitute for it are fighting against the trend of the times. Le Play was wrong when he thought the old stable French family "famille souche" (the stem family) could be restored. Marshall Petain will fail in any similar attempt. Sorokin is mistaken when he believes that the contractual state of family relationships can or will be revived. Hitler and Mussolini are engaged in a losing battle in their reactionary efforts to turn back the hands of time. The trends of family life can only temporarily and not permanently be thrown into reverse.

Many at present are pessimistic about the effects of the war upon the family. Certainly marriage and the family will be subjected to great stress and strain. Without question every effort should be made to protect the family in this period of crisis. But the general effect of this War for Survival as of World War I will be to speed up the changes taking place. The greatest gain in my judgment will be in the increased status of woman brought about by her achievement of more of the substance of equality with man to square with the appearance of equality with which she has been all too satisfied.

There is no evidence that family life of today is less happy than in the past. Even the increase in the divorce rate may in the total accounting represent a net gain of happiness since the dissolution of an unhappy union may contribute its part to net gain in happiness. In fact, there is some evidence that the city family as representing future trends is on the whole happier than the rural family which retains more of the characteristics of the past. A White House Conference study of "The Adolescent in the Family" revealed that on the average the rural child was less well adjusted than the town or city child. Studies in marital adjustment seem to indicate a larger proportion of rural than urban families clustered around average happiness with smaller percentage at the very happy and very unhappy extremes of marital happiness. These findings taken together seem to show not only the present status but the future promise of greater family happiness in the emerging type of family united by the subtle intangible but binding ties of affection, congeniality, and mutuality of interest, adaptable to changing conditions, and utilizing scientific knowledge with intelligence in the solution of its problems.

FEDERAL REGULATION OF BUSINESS ENTERPRISE

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It is obviously beyond the scope of this paper to present an exhaustive exposition of the subject of federal regulation of business enterprise, or even to summarize the Constitutional, statutory, and administrative provisions for such regulation. The purpose therefore will be to present a few observations which I have made during a recent study of a large number of federal regulatory measures. These observations will be presented under two following headings: (1) The Changing Concept of Federal Regulation, and (2) The Broadening Bases of Federal Regulation.

I. The Changing Concept of Federal Regulation

The word "regulate" is found in the Commerce Clause of the Constitution. This empowers Congress "To regulate Commerce with foreign Nations, and among the several States, and with the Indian Tribes."[1] This clause has not been modified by amendment; but there is reason to believe that its connotation has been changed by construction, or usage, with the passage of time. The popular concept of the term within recent years has been that of restriction; but to one who is familiar with the history of our early years it is inconceivable that the members of the Constitutional Convention, meeting in the fall of 1787, should have contemplated the imposition of restrictions upon the struggling infant industries of their time. Nor is it likely that many, if any, of their number possessed sufficient vision to anticipate the problems and difficulties which would emerge with the development of large-scale industry, and the consequent need for restrictive measures. It is therefore reasonable to assume that they intended the word *regulate* to mean only *promote*.

There is evidence to support the view that the purely promotive concept of regulation prevailed for many years. During the debates attending the passage of the Interstate Commerce Act, in 1887, such able lawyers as Senator Evarts, of New York, a former Attorney-General of the United States, contended that the regulatory provisions of the Interstate Commerce Act were un-Constitutional because they were *restrictive* rather than *promotive* of the industries affected.[2] But the restrictive provisions of the act were subsequently upheld by the Supreme Court in numerous decisions. Gradually the public adopted the restrictive concept. In 1912 the Supreme Court, in the Case of Mondou v. New York, N. H. & H. Ry. Co.,[3] construed the term to mean "to foster, protect, control, and restrain, with appropriate regard for the welfare of those who are immediately concerned and of the public at large."

This definition recognizes both the promotive and restrictive concepts and suggests the type of regulation which seems to be evolving, namely, that of government participation. To all intents and purposes the federal government is a participant in the operation of the railroads. So close and continuous is the supervision of the Interstate Commerce Commission over the carriers subject to its jurisdiction that they have acquired a quasi-public character, even though they remain nominally as private enterprises. As the scope of federal authority over business enterprise increases, it is not unlikely that the term federal *regulation* will come to be synonymous with federal *participation*. In this connection it might be observed that the term participation is more apt than the term regulation if there is a sharing of responsibility between the industries and the government.

II. The Broadening Bases of Federal Regulation

Strictly speaking, there are only two Constitutional bases for the federal regulation of business enterprise. These bases are found in the Commerce Clause, previously quoted, and in the final clause of Article I, Section 8, which empowers Congress to make all laws necessary for carrying out the powers expressly granted to Congress or to any other department or officer of the federal government.

[1] Article I, Section 8, Par. 3.
[2] Cullom, S. M., *Fifty Years of Public Service*, p. 230.
[3] 223 U. S. 1, 47 (1912).

It is of interest to note, in passing, that the Commerce Clause remained practically unused during the century following the adoption of the Constitution, the Interstate Commerce Act being the first significant statute based upon it. The Interstate Commerce Commission in its first annual report to Congress discussed the long delay in applying the provisions of the Commerce Clause, and gave as its explanation "the slow expansion of interstate trade."[4]

There could be little question as to the propriety of regulating interstate carriers and communication systems on the basis of the Commerce Clause. But gradually the definition of interstate commerce was expanded to include industries auxiliary to interstate carriers, and later to include firms whose products were intended to be sold outside the state in which they were produced. Statutes such as the Fair Labor Standards Act,[5] popularly known as the Wages and Hours Law, are typical of this tendency to bring within the federal jurisdiction activities which can be called interstate only under the most liberal construction.

The implied powers of Congress provide a basis for the indirect regulation of business enterprise. The economic activities of the federal government have always had their impact upon private enterprise. But recently advantage has been taken of this fact for the purpose of inducing private enterprisers to conform to certain standards of business conduct set up by Congress or some federal agency. The Walsh-Healey Act of 1936 is typical. It provides for the withholding of all contracts exceeding in amount $10,000 from contractors who fail to observe specified requirements relative to the wages, hours, and working conditions of their employees; and it provides severe penalties for violations. While such procedures were certainly not contemplated by the framers of the Constitution, they are accepted by liberals as being in keeping with the spirit of the Constitution.

National emergencies provide occasion for the extension of federal control on the basis of the implied powers, for under such circumstances governmental functions are expanded and redirected, thus increasing their potency as regulatory factors. The present state of war has necessitated the rigid regulation of many industries by the federal government, not merely by means of positive and negative incentives, but through executive orders. Such regulation is in many instances necessary for the successful prosecution of the war, and is therefore justifiable. But experience has shown that powers exercised in an emergency are with difficulty relinquished by the government when the emergency has passed.

In the exercise of some of the express or implied powers it has been discovered that regulation of business enterprise may be achieved where it might not be *purposefully undertaken.* For example, in the exercise of the taxing power it is possible to accomplish a regulatory end, even though a tax imposed for the obvious purpose of regulation would not be allowed by the Supreme Court.[6] Thus, a penalty, or regulatory tax, on oleomargarine was upheld by the Court on the ground that a Constitutional function of government (taxation) must not be defeated on the ground that its effect would be regulatory. But in a later case[7] it was held that if the statute gave evidence on its face that its purpose was to achieve an un-Constitutional regulatory effect, the statute would not be enforceable.

Again, the taxing power has been used to effect general economic changes which have a direct bearing upon business enterprise. Through a proper use of this power in the establishment of rates and incidences of taxation it is possible to induce a redistribution of wealth or income which will materially affect private enterprises. This power was greatly implemented by the Sixteenth Amendment, on the basis of which progressive income taxes are possible.

Tracing the development of federal control one cannot but be amazed at the manner in which the Constitution may be made to apply where regulation is desired. This at once constitutes a basis for optimism and a basis for fear. It is the responsibility of political scientists, sociologists, and economists to use their influence to see to it that these enlarged Constitutional powers are not abused.

[4] I. C. C., *Annual Report*, Vol. I, (1887) p. 2.
[5] *52 U. S. Stat.* 1060ff (1938).
[6] *McCray v. United States*, 195 U. S. 27 (1904).
[7] *The Child Labor Tax Case*, 259 U. S. 20 (1922).

CHICAGO AND THE DOWN STATE

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Keep awake, Peoria. Chicago will not give up. They are only getting their fight started. Get a few shots more into Washington before Chicago catches Peoria with its clothing disarranged so it cannot stand at parade with a presentable condition.[1]

'I have already learned,' said Anthony (Cook County) 'that when gentlemen wish a thing to be beaten, they only have to raise a hue and cry against Chicago, and down it goes. I have never seen such prejudice and malice exhibited against any region as has been exhibited by some gentlemen here against Cook County. The animus exhibited this morning seems to me unworthy of this convention.'[2]

'I am just as proud of that great city as any gentlemen upon the floor can be,' explained McCoy (Whiteside County), 'although I believe it has become a nice question, whether the city of Chicago is in the State of Illinois, or the State of Illinois is in the city of Chicago. I believe that depends on whether you live in Chicago or not.' (Laughter.)[3]

These selections, dated 1942 and 1869 bind together a series of intermittent struggles which have disturbed Illinois leaders for over seventy years. Much like they reputedly do about the weather, many people talk about the situation, but do nothing about it.

This paper grows out a study recently completed at the University of Chicago which tried to answer three questions[4] regarding Chicago—Down State relationships. Its chief sources were: Constitutional Debates and Proceedings; House and Senate Debates[5] and Journals; Records of the City Council of Chicago, Sanitary District of Chicago, and Board of Commissioners of Cook County; publications of committees; newspapers; and personal interviews made over a period of sixteen years by the writer.

A method of approach gave some trouble. The first task was, to define the term conflict—which finally meant a personal, conscious, spasmodic, but rather recurring struggle for individual or sectional advantage which has appeared frequently between persons residing in the two areas here designated, Chicago and the Down State; next, evidences of such conflict, and the reasons for the same had to be found. Committee and organization[6] reports provided some proof. Constitutional Convention and legislative debates gave other clues. Newspaper accounts furnished useful information. The duty of verification followed. Votes by counties cast in legislative bodies by delegates and representatives were recorded on maps of Illinois and studied for evidence of conflict existing between Chicago and the rest of the State. Personal interviews were made as another means of possible testimony as to the findings.

Before these are discussed, a little orientation may be necessary. Illinois entered the union in 1818. Much of the credit belongs to pioneers who migrated from Kentucky, North Carolina, Tennessee, Virginia, and entered the State from the South. Later, settlers came from Maryland, New England, New York, Pennsylvania, remaining for some time in the northern part of Illinois. These two cultures were enriched by a third contribution, made by emigrants from Ireland, Germany, and other foreign countries.[7] According to students of our history, residents of northern and southern Illinois mingled little before the sections were bound together (1856) by the Illinois Central Railroad. Meantime, Chicago was growing. Her population of 350 in 1833 increased to almost 300,000 by 1870.

Other changes are worthy of note. Prior to the year 1900 Illinois was a rural state, but the Federal census of that year showed that 54.3 percent of the population lived in urban areas. Of these, 64.9 percent resided in Chicago. Thirty years later (1930) only 26.1 percent of the State's inhabitants were classified as rural, while 59.9 percent of an urban population of 73.9 percent lived in the metropolis. These factors may explain: why certain *rural-rurban* attitudes have persisted in Illinois from the beginning; why these attitudes came more aggressively into conflict with *urban-metropolitan ideas;* and why certain Illinois cities tended to unite more closely since the year 1905,[8] when they began to

recognize that they had common wants which might, if they united, be satisfied partially by legislative action.

Thus the historical, cultural, and ecological threads were at hand with which to weave the fabric of sectionalism.

The searcher, for two reasons, was early disappointed. First, before the Constitutional Convention convened (1869-70), sectionalism was more a conflict waged between northern and southern Illinois than one carried on between Chicago and the Down State. Second, sectionalism between the latter, although emerging in over one hundred conflicts, was found to be of a more prosaic character than that which had fascinated the student of sectionalism in America.

For the sake of clarity, the writer in the study has followed each class of conflict historically. But it must be acknowledged that this type of approach places the reader at a decided disadvantage, for one is apt to think of these usual biennial disturbances as rather simple affairs. Thus it very often has occurred to the writer that the study might have been better understood if it had been entitled "An Intertwining of Conflicts From the Year 1870," for on several occasions various conflicts have clashed together in the same legislative session, pushing emotions to a high pitch. During these periods much bad feeling was evident, threats were hurled from one side of the house to the other, legislation was slowed down, and often most of the session was one of conflict and uncertainty, with occasional compromises. A study of Convention journals, Chicago and Down State newspapers, and the report of votes set forth in legislative publications serve as proof of this situation.

The legislative session held in 1927 when Small was Governor of Illinois and Thompson became Mayor of Chicago is one example of the point made above. Before the session was six weeks old, Hunter (Winnebago County) introduced a gasoline tax bill, and six attempts, three intended to limit Chicago, were made to deal with the apportionment problem. Later two more gasoline bills, two income tax measures, and a bill by Kessinger (Kane County) designed to regulate the Chicago Board of Trade, were presented. Further, the senate received on May 17 from Chicago five transportation and eighty-seven finance measures. This situation became more complex because three Chicago representatives wanted their favorite intoxicating liquor bills passed into law during the session. The occasion was so tense that Mayor Thompson appeared before the senate and Chicago newspapers not only accused the Small-Thompson machine, but also the farmer members of the Legislature of being "all set to trim" Chicago. Senator Denvir of Chicago protested against the treatment his city had received and introduced a motion that Illinois be formed into two states: one, named Northern Illinois, consisting of Cook, Will, DuPage, Kane, Lake, McHenry, DeKalb, and Boone Counties; another, called Southern Illinois, comprising the rest of the state.[9] The plan died in committee.

The final report showed that the board of trade, income tax, representation, transportation and liquor bills had failed in the Legislature, while the gasoline tax bill and seventy-eight Chicago tax measures were signed by the governor.[10] Such is the history of a legislative session which gave ample opportunity for Chicago-Down State conflict. The *Chicago Tribune* saw "eighty-one perjurers" in the legislature.

Since 1870, Chicago and the Down State areas have disagreed on the following major topics: representation; home rule for Chicago; the waterway and the Chicago Drainage Canal; internal improvements; the judiciary; the wet and dry issue; taxation; and the State's desire to build certain State buildings in Chicago. Of these, representation, home rule for Chicago, and taxation remain live issues perplexing to law makers. The depression added new elements; poor relief and the method of raising funds to meet it, and Chicago's depression needs as compared with the wants of other areas. Besides, Illinois has a Chicago Governor.[11]

Since this paper must be in condensed form, only one problem—representation—is discussed at length. On the surface this question seems to be a constitutional one, but at its foundation the issue appears to be one of control; a struggle for power based on the section and having within it the elements often ascribed to "power politics."

In 1870 the State population was over two-and-one-half million with about 300,000 persons living in Chicago. Then Cook

County had seven representatives in the lower house at Springfield and consequently was allowed seven delegates in the Constitutional Convention (1869-70). There a conflict occurred over the problem of representation. Down State wanted a county basis for apportionment while Chicago-Cook insisted on a population plan. Chicago won because she had excellent leadership. In the legislature which followed, despite sectionalism, Cook County was allowed seven senators and twenty-one representatives, a substantial increase over the previous allotment.

The Constitutional provision, accepted 1870, calls for an apportionment every ten years based on the Federal census. The Illinois legislature is required to divide the population of the State by fifty-one, thus providing a quotient which will be used in determining senatorial districts. Each such district is assigned one senator and three representatives, latter to be chosen by minority representation. The Constitution provides that "senatorial districts shall be formed of contiguous and compact territory, bounded by county lines." This plan has two obvious weaknesses: first, apportionment is a legislative matter; second, with population moving elsewhere, many areas in the State lack direct representation.[12]

The last senatorial apportionment was made forty-one years ago (1901). Before that date Chicago was criticized, but Down State party leaders needed Chicago party votes in order to reapportion the State along party lines, so the metropolis received its quota of representatives in both houses.[13] Since that date, apportionment has been the major issue in Chicago-Down State sectionalism, and the constitutional provisions have been ignored.

Since 1903 Cook County has been able to control such legislation as requires a two-third vote of the membership of both houses before final passage, for that county sends nineteen senators to an upper house numbering fifty-one and fifty-seven representatives to a lower house consisting of one hundred fifty-three members.

Down State leaders have been willing to give Chicago more home rule in purely local affairs on condition that the latter accept a limited membership in the legislature. Such limitation would restore the two-third voting strength in one or both houses to the Down State area. The record of the Constitution Convention held during the years 1920-22 prove this point.

Two illustrations, one political, the other sectional, are given to substantiate the statements made above. The democrats had apportioned and gerrymandered the State (1893) making use of the gag rule and the sick and ignoring the dead in order to do it. Two bills were passed before the task was completed because Riverside (Cook County) had been omitted from the first measure. Down State democrats needed three Chicago votes in order to carry through the proposal which in turn increased Cook County's strength in the legislature by 50 per cent.[14] Illinois republicans were not satisfied, for since 1857[15] that party had carried the State. Two courses, however, were still open: perhaps the court would declare the law unconstitutional; if not, party success at the following state election would give republicans an opportunity to pass a new reapportionment bill. The first plan was tried, but the judges (1895) held the act unconstitutional. Next year (1896) the republican party carried the state.

Again in power, the latter was determined to pass a senatorial reapportionment bill even though Attorney General Akin advised against the procedure. The first attempt (1897) failed because the republicans did not vote unanimously. A party split in Chicago was given as the reason.[16] Dismayed but resolute, republicans caucused at Springfield, heard Governor Tanner exhort them in a doleful message, and determined to try again. The Governor called a special session of the legislature and in his message showed the gravity of the situation from a party point of view. Republican representatives obeyed by passing a new apportionment bill,[17] later the state Supreme Court declared the act unconstitutional.[18]

The sectional conflict over representation reached its zenith in the years 1925-26. Political leaders and newspaper writers made much of the issue. Slogans, a tax revolt, threats of secession, and a mandamus of the legislature all entered into the picture. The issue became immeshed with such problems as daylight saving, public utilities, a gasoline tax, prohibition, and the failure of the legislature to remove the county jail and criminal

courts from Dearborn and Illinois Streets, Chicago. Chicago newspaper headlines read: "Tyrranizing over the City;" "Organizing the State Against Chicago;" "A Sample of Oppression;" "Tax Action Without Representation." Three stalwarts, two from Down State, former Governor Joseph W. Fifer and the Honorable Lewis A. Jarman, appeared before the legislature arguing for the Down State proposal that Chicago be limited; the third, John B. Fergus "the eighty-two year old fighting Chicagion" defended his city at Springfield. While the legislature failed to limit the metropolis at this session, the Schnackenberg (Chicago) motion that the House proceed to a reapportionment of the state along constitutional lines received only five votes from counties other than Cook.[19]

Chicago aldermen advocated that Chicago secede from the State of Illinois and instructed Corporation Counsel Busch to outline the legal steps in the process. Mayor Dever (Chicago) appointed a committee whose business was "to secure constitutional apportionment for Cook County" so talk of secession subsided for a time. The Hamilton Club of Chicago selected a committee of seven, representing both opposing sections of the state, whose duty it was to find a solution to the reapportionment problem on the basis of "sober and intelligent thought." This committee favored a compromise between the sections. Fergus carried the fight to the Supreme Court of Illinois and finally to the United States Supreme Court. The courts refused to interfere in what the judges considered a legislative problem.[20] Today the issue—representation—remains in the realm of conflict.

As mentioned above, ecological changes have forced Illinois leaders, at times, to cooperate on certain issues. Representation is one of these. A study of fourteen divisions on that subject made during a thirty year period (1901-1931) revealed that Chicago had some cooperation from legislators representing thirty-five Down State counties.[21] Peoria voted eight times with Chicago.

When one searches for causes which brought about conflict between these areas one must keep in mind that the real reasons may remain in obscurity, while lies, truths, and past statements may be effectively used by persons who seek advantages for themselves. With these thoughts in mind, two lists of causes are given in explanation of these periodic disturbances.

Since Down State representatives have been more aggressive in dealing with the problems at issue, their reasons are given first. Expediency—"the end sought justifies the means"—is the most subtle argument given by them for their persistent nullification of the Constitution. This is followed by three arguments: other states limit metropolitan cities—New York and others; the present system of representation is virtual, not direct; the population method of apportionment should give way to one based on electors or citizens. The statement is then made that Chicago will dominate the state which means the following: control by a unit; a city of one interest; a city which sends undesirable Chicago interested legislators to Springfield; a city with a population of a size, type, and attitudes which are considered undesirable; a city of crime. Then follows a most interesting argument: Chicago needs protection.

Since Chicago leaders were on the defensive, they were content to put forth four reasons in justification of their attitudes toward the Down State First. "Chicagoans object to discrimination giving their city less than its proportionate representation in the legislature." Said one, "In my opinion it will make a Mason-Dixon line out of the Cook County line." Second, the Down State position is one of fear. Third, limitation deprives industrial centers of representation, and gives control to areas which are decreasing in population. Fourth, Chicago pays most of the state taxes. Leaders in both areas emphasize the idea of domination in speaking of the aims of the other party to the conflict.

The following reasons seem to better answer the question as to why these areas have difficulty in cooperating. They are given as a result of the writer's reading and questioning over a period of years: the ever-increasing size of Chicago; the parental attitude of Down State toward Chicago; fear of the growing city; desire for public office; methods employed by politicians to secure votes and win elections; desire for control when in office; a busy press; lack of adequate knowledge; conflicting theories of government. Because Chicago lacks home rule she has easily been exposed to Down

State criticism; mere number of requests from the legislature, made necessary by constitutional procedure, have often produced bad feeling through almost an entire legislative session; Chicago delegations failed to plan in advance for the work under consideration, thus giving Down State members a chance to say that they did not exactly know what the people of Chicago wanted; Chicago representatives often disagreed among themselves and failed to act as a unit; they have been accused of lack of interest in the state as a whole.

Other reasons have been given by Down State at different times, all of which were applied to Chicago: election frauds; failure to collect taxes and pay school teachers; the large sums of tax money needed for relief purposes, despite the fact that the city was millions of dollars behind in tax collections; the crime wave; Chicago has sent many mediocre men to the legislature. Chicago has been poorly advertised at Springfield on important occasions by some of her most public-minded citizens, who in their zeal to reform local conditions in the big city have spoken too publicly at critical moments. To these may be added differences growing out of the cultural heritage of these areas.

In its wider aspects the conflict may be called sociological and political. Sociologically, the problem concerns the attitudes, the social heritage, and the aspirations of people; while politically, the problem involves theories of representation—population, county, and virtual—a subject which is joined with the desire for home rule and at times is augmented with the demand for a new constitution to replace the inadequate one accepted in 1870.

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[1] *Peoria Journal-Transcript,* January 13, 1942. Rex Post, "Diversion" in *The People Speak.*

[2] *Constitutional Convention Debates,* 1869-70, p. 1661.

[3] *Ibid.,* p. 387.

[4] Does conflict exist between Chicago and the rest of the state? What subjects are responsible for such conflict? What reasons lie behind the conflict?

[5] *House Debates,* 1915, 1917; *Senate Debates,* 1915, 1917, 1919.

[6] Annual reports—Citizen's Association of Chicago; Federation Reports and Bulletins; Chicago Bureau of Public Efficiency publications; Legislative Voters League; Assembly Bulletins.

[7] A. C. Cole (Editor), *The Constitutional Debates of 1847,* shows only seven native Illinois delegates in the Convention.

[8] Illinois Municipal League became active about this date.

[9] Ninety-four counties.

[10] Only nine Chicago tax bills failed of passage.

[11] Henry Horner (1933); others were Beveridge (1873); Altgeld (1893); Deneen (1905-1913); Dunne (1913).

[12] Under the act passed (1901) the number has varied the lowest number being seventeen counties (1903 and 1907), and the largest, thirty-three (1927 and 1931).

[13] See *Senate and House Journals,* 1881, 1891, 1893, 1897.

[14] Senate from 10 to 15; House from 30 to 45.

[15] Governor Wm. H. Bissell.

[16] The trouble seems to have occurred in the twelfth ward (third district) of Chicago where an "out group" was in control.

[17] *Senate and House Journals,* 1897 *(Special).*

[18] April 30, 1898.

[19] Clinton (Southern Illinois); Peoria, Will, Winnebago (partial support); DuPage.

[20] Fergus V. Marks (1926); *United States Reports,* vol. 279 (1929).

[21] Clinton (3); DuPage (4); Macon (3); Madison (3); Peoria (8); Will (4); Winnebago (4); Edgar (2); Fulton (2); Lake (2); LaSalle (2); Marion (2); Mercer (2); St. Clair (2); Kane (2). Twenty others voted once.

HAMLET AND VILLAGE POPULATIONS IN ILLINOIS

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This paper is a report of four investigations pertaining to Illinois hamlets and villages. As measured by population, hamlets are communities with less than 250 inhabitants, while villages have at least that number but less than 2,500.

I.—In 1912 an article in The Journal of Political Economy contained a prediction that many of the then existing hamlets and villages in Illinois would decline in population and disappear. This was based on the assumption that improvements in the means of communication and transportation would eliminate the need for as many small communities with their local business establishments as existed. The aforesaid prediction has *not* been fulfilled so far as *incorporated* hamlets and villages are concerned. This is proved by Bureau of Census records which show 922 incorporated hamlets and villages in Illinois in 1910 and 934 in 1940.

Incorporated hamlets and villages constituted only 44.4% of all hamlets and villages in 1930. From this fact it is clear that the validity of the prediction in question cannot be judged by data partaining only to incorporated communities. Serious difficulty is encountered, however, when one undertakes a study of unincorporated hamlets and villages for no precise statistical data are available regarding them. In spite of this students have assembled such data as they could procure. The most complete recent study of such communities in Illinois, so far as the author knows, was published in 1938. It reports that in 1930 the number of such places was 357 less than in 1910. This conclusion arouses curiosity about the source of information. When that is examined, one finds that what this recent study actually discovered was that in 1930 there were 357 less unincorporated communities in Illinois *that contained one or more business establishments rated by a national financial agency* than was the case in 1910. But the disappearance of business establishments does not necessarily indicate the extinction of the hamlets and villages in which they were located. The author of the study in question recognized and acknowledged this fact. No available evidence known to the author demonstrates the validity of the prediction that Illinois hamlets and villages would disappear as the means of communication and transportation improved.

II.—The second investigation shows that a correlation, but not a direct causal relation, exists between the size of hamlets and villages and the probability of their growth or decline. Larger percentages lose population each decade of hamlets and small villages than of large villages. Tests of this were confined to incorporated hamlets and villages. These communities were classified under three categories, namely, places with populations of less than 500; of 500 to 999; and of 1000 to 2499. The percentages of each class of community which lost population beginning with the largest are:

For the decade 1920-1930, 46.4; 62.2; and 73.9.

For the decade 1930-1940, 22.9; 22.4; and 39.5.

The correlation postulated above was found to exist in an analysis of incorporated hamlet and village population changes in 75.6% of 36 states for the last intercensal decade and in 86.1% of these same states for the decade 1920-1930. Size is not in itself a direct cause of population changes but the causes of population changes are, with a high degree of consistency, related to size, so that the smaller the place the more liable it is to lose population and the larger the place the less this liability.

III.—The third investigation was conducted to test the hypothesis that proximity to urban centers lessens the liability of hamlets and villages to lose population while remoteness from such centers increases that liability. Only incorporated hamlets and villages were considered. The investigation consisted of a study of six cities in Illinois selected on the basis

of size and distance from other competitve communities. Around each of these cities three concentric ten mile wide zones were marked and the number of hamlets and villages in each zone and the numbers of them which lost population during the last decade were counted. Communities were classified under four categories, instead of only three as in the last investigation, by making hamlets into one class and villages with populations of from 250 to 499 inclusive, another. The assumption was that if the hypotheses were valid the percentages of communities which lost population would be greater in zone three, the most distant one, than in zone two, and greater in zone two than in zone one. Because communities were divided into four categories this test could be applied to each category for each city and also to the totality of all communities for each city. This provided 30 opportunities to test the validity of the hypothesis. Four of these had to be discarded because of the lack of hamlets of certain categories in some of the zones. In only 7 instances out of 26 did the percentages of communities which lost population increase with the distance from the urban center. In 19 cases out of 26 no progression is exhibited. In other words, conformity to the criterion employed to test the validity of the hypothesis was found in only 27% of the tests, which means that in 73% of the tests the results were negative. Similar tests were applied to a study of 5 cities in Iowa and to an additional 6 metropolitan cities and with much the same results. In the tests for these 11 cities conformity to the criterion was found in only 22% of the cases, while 78% were negative.

From these facts we are forced to conclude that proximity to urban centers does not lessen the liability of incorporated hamlets and villages to lose population nor remoteness from such centers to increase such liability.

IV.—The fourth investigation was to ascertain whether any significant correlation exists between the percentage of people on relief in Illinois counties and the growth or decline of the hamlets and villages in those counties. The five counties which had the smallest percentages of their population on public relief in 1940 were contrasted with the five counties which had the largest percentages on public relief.

In each of the five *low* relief counties a majority of the hamlets and villages *gained* population. However, in two of those counties the number that gained population was only one greater than the number that lost. In the other three counties the number that gained was a sufficiently large majority so that the percentages of all hamlets and villages in the five *low* relief counties that *gained* population was 71.4%. In contrast, a majority of the hamlets and villages in the *high* relief counties *lost* population, the percentage that gained being only 46.6% of the total. This seems to indicate that *low* relief is correlated with the village growth and *high* helief with village decline. When losses and gains are studied by counties, however, the correlation disappears. All of the hamlets and villages in one of the *high* relief counties *lost* population while in another all of them gained. In two of the remaining three counties a majority gained while in one the majority lost. From these facts we conclude that no significant correlation is established between the percentage of people on public relief and the tendency for hamlets and villages to increase or decrease in population.

THE FATE OF THE FAMILY

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The family, like any other institution or a living organism, leads a double existence. It has an internal life. Its internal structure and functions must serve its own constituent elements. These elements, in turn, or the organization itself, play a role in relation to other elements, organizations, and institutions. The family has a life of interaction with them, a life observed as external.

If or when one dares to speak of the future of an institution, there is involved the entire social structure of which it is a part. Therefore, one's task would seem to be the assessment of the entire cultural structure and functions, as well as the cultural patterns involved.

The family is at once the creator, and is created by, the general cultural world of which it is a part. It has become common knowledge among sociologists that in the family are originated all of the essential elements of the personalities of its members, the basic elements of humanness. In Cooley's phrase, the family is "essential to the genesis" of human nature.

The truth of this basic conception has been amply demonstrated since it was first expressed in Social Organization in 1909. There is evidence of two varieties. First, personality disorganization cannot be explained or understood fully without realization of the inadequate functioning of the family group of which the disorganized personality is or has been a member. Second, the prediction of failure or success of a particular marriage, although the technique is still in its infancy, has gone far enough at the moment to demonstrate that cultural background factors of each of the persons marrying, form a cornerstone of prediction. The late Dr. Meroney demonstrated, for example, that there were three possible attitudes in the person coming from a home situation where tension was predominant in the relations of the members. First, there was the possibility that children growing up in such a condition would refuse to marry; second, they might accept the condition of tension as a pattern of behavior so that in marriage there would be a repetition of the conditions in the original home; third, there might be special effort to avoid tension. A former student confided to the writer that when she married there were going to be special precautions taken against a repetition of the condition of tension which finally led to divorce in the family in which she had grown up.

The principal constituent element furnished by the family in the production of personality is intimacy. The term intimacy includes all relationships involving the entire family group. It is not limited to the physical and psychosocial intimacies of the sex act. The response function is a basic one. The family is the organization, the world over, which satisfies this desire. The form of the marriage over most of the earth's surface is monogamous. It seems to be the form of organization that is especially well adapted to produce the personalities which, in turn, are best adapted to function in a complex world. Most of the peoples of the world, the assumption is, are partisans of monogamy, and being thus partisan, we must observe with many misgivings the temporary and artificial arrangements made in some of the totalitarian countries. It may be, however, that when a young woman is persuaded that her function in life is to produce babies for Der Fuehrer and that this is "much nobler, much grander, than having a home and a husband," that better soldiers will be produced than we could with our type of family organizations.

Our conclusion must be drawn conditionally, therefore. If someone like Adolph Hitler does not succeed in organizing the world of the future, something like our form of the family will persist. Human nature will continue to be born in some sort of intimacy of relationship.

Indeed, one might go farther and ask if the family organization itself is not the principal reason why human beings will never find satisfaction in a totalitarian society. In intimate relationships there inevitably is an approach to equality. The universality of the demand for satisfaction of the wish for response leads one to wonder if there could be a long-range program based on totalitarianism. The experience which the Soviet Union has had in its experiment of complete freedom for members of the family would seem to be evidence on this point.

This leads us directly to the question of the relation of the family with other institutions. It would seem that the types of personality we produce in our families will tend to determine the nature of other institutions, particularly political and economic organizations. But these, in turn, will tend to determine the type of family organization.

What is the general outlook for the future, assuming that there is anywhere sufficient wisdom to make an intelligent guess? Pitirim Sorokin has spoken recently to the question in *The Crisis of our Age*. His argument has been reviewed both favorably and adversely.

It must not be assumed that Sorokin is entirely pessimistic with reference to the future of the family, for in one place he says, "Genuine contractual relationships—not fictitious ones—can and will eventually be restored." In another place he expresses his faith that society will enter upon a "new, integrated, stable, orderly, and creative phase of its existence." In spite of the dark picture which this author paints of the transition through which society is passing, he believes that the conceptions set forth are among the most optimistic concerning "socio-cultural change."

Right or wrong in detail, we shall have to agree with Sorokin that there are forces operative over which even the dictators have little or no control. They themselves are to be explained as products rather than as originators.

If there should come about an ideational or idealistic culture as Sorokin insists that he is optimistic enough to believe, then there will persist a family not greatly different from the type which we now have. It might even be that the evidences of family mal-functioning, such as our high divorce rate, would to some extent disappear. There will be predominant in such a culture values that Sorokin calls "absolute." One of these absolute values will be a recognition of the preponderant importance of human personality. If this is to be a value of the future and personalities find their genesis in the family, then the institution which, more than any other satisfies the need for intimacy of relations will continue to be of predominant importance.

IS THE FAMILY PASSING?

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Theoretically, two things can happen to the family: it can remain very much the same as it now is in our society, or it can change. If it changes, it can change in either of two directions: it can lose its importance as a social institution, even gradually disappearing and being replaced by other institutions, or it can grow stronger and socially more significant.

An examination of our culture and its development indicates that the family can hardly be expected to remain as it is. In an age when practically everything is in flux, even the basic moral codes of our society, it is useless to think long of a far-flung institution like the family, which touches practically all phases of our lives, remaining isolated from the process of change. Then, again, if we use the experience of the past as a guide, the family may be expected to undergo changes inasmuch as changes have occurred in its nature and function in recent decades, these changes continuing even into our present time.

The facts of changes themselves, as well as the direction of these changes indicating somewhat the future fate of the family, may well be reviewed briefly in support of the statement that changes have taken place in the family and are still in progress. The significance of these changes for the future of the family will also be of interest.

One of the most evident changes in the last century is the transfer to other institutions of functions previously performed by the family. The industrial factory has largely taken over the making of cloth and of garments, the laundering and repair of clothing, the canning of foods and the baking of bread and pastries, and to some extent, the cooking and serving of meals, all of which were formerly the almost exclusive function of the family in its own home environment. The family has changed industrially from a production to a consumption unit.

What does this transfer of industrial production mean to the family? Some have feared that it means a definite step toward the ultimate dissolution of the family. An examination of the facts indicates that the transfer has meant that cloth, lint, looms and other materials with their noise and clatter have been taken out of the home to modern factories built, for the most part, to perform the work of manufacture under better lighting, ventilating and sanitary conditions than the home affords. If the increased leisure time provided by this transfer can be filled with cultural and wholesome recreational activities in the home, the change is a definite gain for the family in this respect. There is one way, however, in which the bonds of the family are weakened by this shift. The members of the family in our grandparents' day worked together very much as an industrial unit and were in constant close communication because of this fact. Unity of belief and attitudes among the family members was a natural result of this close association. On the other hand, members of the family of today often scatter widely in attending to their various duties and activities and usually come in contact with beliefs and attitudes which are very different from those of the family. Adoption of different viewpoints in this natural course of association leads to greater disharmony in the family than was true in former decades. I may point out here also, that this exposure to different viewpoints has some beneficial effect when it breaks the bonds of narrow prejudices which so often thrive in the isolated soil of a close family unit. While industrialization has broken the unanimity of family attitudes and opinions, it has also paved the way for greater tolerance of new viewpoints and thus for cultural change and progress in general. It is evident that the rural family which still works as a single industrial unit to some extent is less affected by the transfer to industry than is the urban family, although power farming, good roads, the auto and the radio are tending to close the gap of any

such difference between rural and urban families.

In a somewhat similar manner the family has been affected by the transfer of religion from the home to the church, of formal education from the home to the school, and of recreation to commercialized recreation agencies. But insofar as these new social institutions perform their tasks more effectively than the family did, the family is merely relieved of these functions and is free to replace them with added family services and enjoyments. Actually, the school is probably the only one of these three types of agencies which is doing better work with its assignment than was being done in the family. It does its work so well largely because it took over only the formal side of education to which it is adapted, leaving the informal part still chiefly in the hands of the family.

Religion seems to have gotten lost to a considerable degree somewhere in the transfer from the family to the church, and commercial recreation, although improving in recent years, leaves much to be desired in comparison with the home and neighborhood recreation of the age just past. While public community recreation is assuming a new and increasing role that has definite family value, one wonders if there is not still lacking to a considerable extent in both public community and in commercialized recreation the personalized element that made the family recreation of the past so satisfying to the individual. Family days at church and family picnics in parks and playgrounds are illustrative of constructive family activities since the transfer referred to has taken place.

The functions yet left to the family are the rearing of children and the emotional satisfactions of affection among its members. Because the family has so few of its earlier functions remaining, there are those who fear the family is passing to an unimportant and insignificant position among our social institutions. This viewpoint fails to take into account two very important facts. In the first place, the new conditions of society, especially the vast increase of anonymity and impersonality of relationship, have given greater emphasis to the need for affectional response of individuals on the personal basis of family life so that the remaining functions of the family, affection and child-rearing, have greatly increased in relative importance. In a desert world of anonymity and personal indifference, the family is the one remaining oasis of personal relationship, solicitous attention, and affection. It is quite possible that this affectional function of the family has already assumed such major importance that it not only overshadows the other earlier services largely transferred to other social institutions, but that it gives such present significance to the family as to make it more important than before.

The second fact to be remembered is that many of the functions, given up by the family have left more time and space for the family to concentrate its efforts on those peculiarly vital functions that remain to it.

The increasing number of divorces and separations of married couples has worried many people interested in family life. It seems likely that these separations denote increased emphasis on the emotional element in marriage inasmuch as couples separate when they are emotionally disappointed in marriage. Formerly, unhappy couples were generally bound to stay together because of the economic dependence of the wife and the expectation of the *mores* of society. But persons who separate today remarry. The proportion of the population married was never higher than today.

The present status of the family seems then to be that family life is more desirable than ever before, but persons undertaking the establishing of family relationships must find these relationships emotionally satisfying or they will sever them in the hope of making other and more satisfying attempts. The transfer of certain functions has meant that the family has changed, but it has not become less important.

The family has changed also with respect to authority. The patriarchal family rule has been giving place to equalitarian practice. Whereas, a century ago in this country a wife was legally a dependent of her husband, was denied admission to colleges, was not permitted to vote, and had very little voice in determining her own life much less that of her family, today all this has changed. Formerly husbands divorced wives but wives seldom divorced husbands, while wives today make the applications for

divorce against their husbands in about 70 per cent of the divorce cases.[1]

This increasing freedom of women no doubt contributes to the breakup of individual families which are not satisfactory, particular to wives. As cited above, however, this does not mean a decline of of the family as an institution so long as remarriage keeps the total per cent of married persons higher than it was before the change took place. It must also be borne in mind that marriage and family life that is maintained on a free and voluntary basis because people care for each other is a higher type of family relationship than that which is enforced by economic necessity as was true in many cases of the period previous to the present day.

Still another change in the family is the decrease in the number of children. The average number of children in the present day family is less than half that of a century ago, and the trend is for still further decrease. This is probably a greater hazard to society as a whole than it is to the family institution itself. Family life may go on even with an average of one child per family, but population rapidly decreases on such a propagation rate. It appears that family limitation at present is affecting most the middle class of American society. Here young couples anxious to maintain their standard of living forego children until they become established in business or in a profession.[2] Then they settle with nature by having one child. It may be that Myrdal's criticism of birth limitation in Sweden has some appropriate application in America when it is said Sweden's radicalism, attempting "to adjust the size of the family to social malformations, did not materially readjust the malformations but led in the direction of extinguishing the human content of society."[3] The problem involved in the decrease of the size of the family concerns society probably more than it does the family. It seems likely that society must eventually be willing to make family economic conditions easier if it wants the family to yield more children. Certainly America has reason to be concerned about the survival of its sturdy middle class. The family is going on but it seems destined to be a smaller family unless some better provisions are made for it.

[1] Bureau of the Census, U. S. Department of Commerce, "Marriage and Divorce, 1931." U. S. Government Printing Office, Washington, D. C., 1932, page 20.

[2] See Folsom, J. K., *The Family*, Wiley & Sons, 1934, pp. 255-257, 265, and 266.

[3] Myrdal, Alva, *Nation and Family: The Swedish Experiment in Democratic Family and Population Policy*, Harpers, 1941, p. 4.

Papers in Zoology

From the Report of the Section Chairman

Twenty-five papers were contained in the program at the Urbana meeting, 16 of which are herewith published. One from the Collegiate Section is also printed. Titles of papers in the Senior section not printed are as follows:

Gearhart, H. E., Edwardsville.—*Wildlife conservation as a part of soil conservation.*

Mohr, C. O. and Yeatter, R. E., Illinois Natural History Survey, Urbana. —*Distribution pattern of pheasants and quails in Illinois.*

Hill, Collan, Southern Illinois Normal University, Carbondale.—*A southern Illinois heronry.*

Gloyd, H. K., Chicago Academy of Sciences, Chicago.—*A preliminary report on a herpetological survey of Illinois.*

Thompson, D. H. and Bruno von Limbach, Illinois Natural History Survey, Urbana.—*Bass and bluegill feeding experiments.*

Lowrie, D. C., Chicago Academy of Sciences, Chicago.—*Distribution of spiders in the Indiana dunes associes.*

In a separate section, a symposium was held on "Interrelationships of Insests with Other Organisms." Three of the six papers given are herewith printed; the others were:

Emerson, A. E., University of Chicago, *Entomophagy of solitary forms.*

Metcalf, C. L., University of Illinois, *Parasites and vectors of pathogens.*

Ross, H. H., Illinois Natural History Survey, *Insects as food of vertebrates.*

Between 40 and 50 attended each of the two sections.

H. H. Ross, Illinois Natural History Survey, Urbana, Illinois, was elected chairman for the Jacksonville meeting in 1943.

(Signed) Orlando Park, *Chairman*

NEW RECORDS FOR THREE ILLINOISAN ORTHOPTERA*

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My paper concerns the giant walking stick, *Megaphasma dentricus* (Stal), Phasmidae, the slightly musical cone-head, *Neoconocephalus exiliscanorus* (Davis), Tettigoniidae, and the Carolina mantis,—our only native mantid, *Stagmomantis carolina* (Joh.), Mantidae.

The Giant Walking Stick. The wingless adult female specimen at hand seems to be the first of this species recorded from Illinois. It came to me through Mr. Roy E. Dively, instructor in high school biology at Red Bud, Randolph County, Illinois. Measuring 139 mm. in length, this individual was obtained alive at Red Bud late in October, 1941, on a portable water tank in a little-used private lane about a mile from a main road and 2.5 to 3.0 miles from a railroad.

The giant walking stick occurs largely in the southern states, being known from Alabama, Louisiana, Texas, New Mexico and Louisville, Kentucky (Blatchley), and from the Ozark region of Missouri (Somes). The northermost points from which Somes recorded it were Hamburg and Clarinda, Iowa, near northern Missouri, between latitudes 40°, 30′ and 41°. Inasmuch as Red Bud is situated considerably farther south,—or at latitude 38°, 14′, and but slightly above Louisville, it may probably be supposed that southern Illinois falls fairly well within the natural distributional area of this phasmid. But since it has been taken but infrequently in this and higher latitudes, Red Bud seems to represent approximately the northernmost line at which the species may be expected to occur naturally without the aid of man-made agencies.

The Slightly Musical Cone-Head. So named by Davis (Blatchley) because so large a meadow grasshopper produces so very faint a call, this green long horn "has been very rarely encountered except on the Atlantic coast from Long Island to Virginia" (Hebard). Records cited by Blatchley indicate it occurs also in Tennessee, as far west as Texas and as far north as New Harmony, Indiana. The first record for Illinois is credited by Hebard to Hunter who located "a considerable colony" of this species at Tower Hill,—latitude about 39°, 20′. This instance represented also the "northwestern limital record" within the United States. I am now able to extend this northern limit to latitude about 40°, 8′ by virtue of an adult female specimen taken at a light by Ruth Agate (Mrs. Garland Riegel) in Champaign on August 8, 1940.

The Carolina Mantis (see table I). Its front legs admirably fitted to seize living insects on which it feeds, this species of mantis occurs commonly in the southern states from Florida to Arizona (Rau and Rau), and northward in diminishing numbers to central Illinois. The principal papers describing its bionomics are by Riley (1869), Rau and Rau (1913) and Roberts (1928). The latter two cite many references to other literature.

Concerning its distribution in Illinois, Hebard (1934) expressed his belief "that the northern limits must be given as Quincy, Olney and Centralia." This statement was made in part on the basis of 19 adults and several juveniles and egg masses in the collection of the State Natural History Survey. These communities lie between 38°, 32′ and 39°, 57′ latitude. I am presuming Hebard's statement is to be interpreted as signifying that those points form the northern limit at which the species occurs perennially. Perhaps a somewhat clearer picture of distribution will be obtained if we think of this, and any other insect species living under natural conditions, as varying its range from time to time within certain geographical limits. The factor regulating the direction and extent of this variation in range in the case of our mantis is perhaps winter temperature in relation to the egg mass or oötheca, which forms the only stage that passes the cold season in latitude of Illinois. We

* Contribution No. 231 from the Entomological Laboratories of the University of Illinois.

may, therefore visualize a strip of territory, extending east-west across the state, in which this mantis vacillates at irregular periods in accordance with variations in degree of winter cold above and below critical points. What the critical temperatures are may possibly be determined by experiment. This strip is bounded on the south by a line of latitude beyond which the species never retreats, because the winter temperatures are continuously tolerable to the eggs, and it is bounded on the north by another line beyond which the species never advances because sooner or later there comes a winter with such low temperatures as destroy the eggs and thereby set the species back southward again.

What the extreme boundaries of this area of vacillation are has, of course, not been learned. But that it involves Champaign county is suggested by the records of four living adult specimens taken in the city limits of Champaign in the early fall of 1940 and 1941. The individual secured in 1940 was brought to the Department of Entomology at the University by an unidentified citizen, and three females were taken in 1941 by Charles Hirsh in a vacant lot near the campus. How much farther north the year-around temperature is sometimes favorable to the survival of the eggs, and therefore to the development of the cycle during the warmer seasons, can be determined only by securing additional records.

However, the potential range of natural distribution may not be accepted as being coextensive with known records of occurrence. Being large, and inspiring popular hope of aid in the war against hostile insects, this mantis is subject to deliberate dissemination by man. Moreover, the egg masses, nymphs and adults that chance to occur on man's vehicles that roll along highways and railroads, or are borne on nursery stock and manufactured articles of numerous kinds, obtain "lifts" that take them quickly far beyond their normal limits. The female taken at Chicago on a lumber car (Hebard), the Staley nymph which I discovered on weeds by a junction of two railroads whose southern terminal is Springfield, Illinois, and the two adults taken on box cars at a grain elevator at Peoria and made available to me by Frank Hasbrouck, are probably instances of such artificial transportation. In the older literature we find further evidence of such cases. Walsh and Riley (1868) reported an egg mass was sent to Lacon in Marshall County from a southern point in the state, and the pair described by

TABLE I.—ILLINOIS RECORDS OF *STAGMOMANTIS CAROLINA*

Locality	Specimens	County	Approximate Latitude	Sources of Records
Metropolis	2	Massac	37°, 8′	Hebard (1934)
Pulaski	3	Pulaski	37°, 13′	Hebard
Dongola	2	Union	37°, 22′	LeBaron (1870)
Carbondale	1	Jackson	37°, 45′	Hebard
Pinckneyville	1	Perry	38°, 6′	Hebard
Dubois	1 j. and egg mass	Washington	38°, 12′	Hebard
Ashley	1	Washington	38°, 20′	Hebard
Keensburg	1	Wabash	38°, 20′	Hebard
Waterloo	1	Monroe	38°, 20′	Hebard
Fairfield	2	Wayne	38°, 20′	Coll. Dept. of Entom.
Browns	1	Wabash	38°, 22′	Hebard
Centralia	1	Marion	38°, 22′	Hebard
Olney	1 ♀ and egg mass	Richland	38°, 42′	Hebard
Edwardsville	1	Madison	38°, 48′	Hebard
Vandalia	1	Fayette	38°, 58′	Hebard
Decatur	1	Macon	39°, 50′	Coll. Dept. of Entom.
Quincy	1	Adams	39°, 57′	Hebard
Staley	1 j.	Champaign	40°, 6′	Coll. of W. V. Balduf
Champaign	1	Champaign	40°, 6′	Coll. Dept. of Entom.
Champaign	3	Champaign	40°, 6′	Charles H. Hirsh
Peoria	2	Peoria	40°, 44′	Frank Hasbrouck
Lacon	Egg mass	Marshall	41°, 4′	Walsh and Riley (1868)
Chicago	2	Cook	41°, 50′	Hebard
	Egg mass	Ogle	42°	Riley (1867)

LeBaron (1870) was mailed to him, presumably at Chicago, by a friend at Dongola in Union County. The possibility of deliberate or accidental participation by man in the dissemination of the mantis therefore clearly renders it impossible to know with certainty whether specimens found in the central area of Illinois are normal residents or adventives. But if found considerably south of central Illinois they may usually be regarded as permanent residents, while if north, or in general decidedly beyond latitude 40°, they would seem to be artifically imported and therefore doomed to local extermination with the coming of the first critically cold winter.

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EFFECT OF TESTOSTERONE PROPIONATE ON TERRITORIALITY IN FLOCKS OF RING DOVES

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A characteristic of bird flocks receiving much attention is territoriality. In studies of the organization of flocks, a significant relationship between this characteristic and the development of social hierarchies has been pointed out by several investigators. Hierarchies of two types are recognized. These are the stable peck-order as reported in chickens (Masure and Allee, '34) and the much more flexible peck-dominance as found in pigeons (Masure and Allee, '34, and Diebschlag, '41), of ring doves (Bennett, '39), and of canaries (Shoemaker, '39). Investigators of peck-dominance have suggested that the explanation of this condition is in some complexity in the form of territoriality developing in flocks.

Shoemaker ('39) observed in canaries that a bird, which is dominant over another in neutral territory, normally becomes subordinate in the nesting territory of the other bird. He says, "This factor alone would account for the peck-dominance type of social organization." Diebschlag ('41), in an analysis of the social order in a heterosexual group of pigeons, concluded that the peck-dominance system is entirely a matter of territoriality. He states that each animal attempts to fix the limits of and to defend a certain amount of space against other members of the society. Since the distribution within a dovecote shifts somewhat easily and rather frequently, he concludes that this flexible "place-order" prevents a "linear dominance" such as that found in the chicken. Both Shoemaker and Diebschlag see in the instability of territorial relationships, in flocks of canaries and pigeons respectively, a probable explanation of peck-dominance.

In ring dove flocks, experimentally treated with an androgen (Bennett, '40), a tendency away from the characteristic peck-dominance type of social order toward a peck-right was observed. As this accompanied an increase in territoriality, the hypothesis was advanced that the possible "explanation of the increased stability observed may lie in the expression of territorialism rather than in any new development." In most of the flocks of ring doves observed, previous to treatment with an androgen, certain individuals had shown distinct territorial tendencies. They "adopted definite locations in the cages and tended to defend these against all intruders." If added to these in any flock, there were others in whom territoriality could be induced by experimental treatment, it is to be expected that a greater degree of stability would appear in the social organization of the group. The present report follows an attempt to analyze more fully the data in the ring dove investigation from the standpoint of the relationship of increased territoriality and accompanying changes in social organization.

The experimental birds, that is, those injected with an androgen, were selected because of low rank, a status characterized either by passivity or by failure to win in pecking encounters. They seldom if ever attempted defense of a location. The general procedures used are fully described in previous reports (Bennett, '39, '40). Three homosexual caged flocks, one of females, two of males, were observed daily. Records of individual locations and activities were recorded in five-minute intervals, making the reconstruction of a cage picture for any given time a possibility. Pre-injection (control) periods were followed by experimental periods. In the latter, one or two of the selected flock members in each cage received daily injections of testosterone propionate. Post-injection periods followed. Two series, one of 78 days, one of 50 days, included 48 days and 24 days, respectively, of injections. The treated birds in Series I were D and RH in the female flock, two birds in male flock A, and EB in male flock B. Three of these, one from each flock, were again experimental subjects in Series II.

In the pre-injection period of Series I both experimental female birds were passive, located much of the time on the front perch. In the injection period, D moved to the floor with occasional aggressive sallies upon the perches. RH first changed from the front perch to the back, then also located on the floor for the remainder of the period. In the post-injection period both birds soon retired to the front perch and became as passive as preceding treatment. In Series II, D again returned to the floor but alternated between it and the front perch. Again, upon cessation of injections, D became passive on the back perch.

The behavior of EB in the male flock B was characteristic for the treated males. In the pre-injection period of Series I, he was never definitely located. He engaged in frequent floor encounters, losing most of them. With injections, he began winning encounters. After three weeks, he located for a time on the front perch. With an increase in androgen dosage later in this series, he returned to the floor. Here the other birds exhibited a wariness with regard to him. In the post-injection period, he gradually became inactive on the back perch. With re-injection EB returned to the floor, becoming an aggressor there. In the succeeding post-injection period he once more settled passively on the back perch.

The androgen induced aggressiveness in the experimental subjects. As this occurred, the same birds exhibited an increased tendency to occupy new locations and to engage intruders in combat until these intruders would withdraw from the place. It was noticeable that the floor was the usual arena of defense activity. This is to be expected because of the space and freedom permitted during combats. With cessation of injections the resumption of the pre-injection status was accompanied by a decrease in the stability of the flock structure.

The flocks observed by Diebschlag and Shoemaker were heterosexual and behavior, directly associated with the breeding cycle, complicated the picture. Since homosexual flocks were used in the case of the ring doves, the influence of sex interrelations was, in part at least, removed. Whatever changes in flexibility of social order occurred were less obscured by mating and nesting activities.

Increased aggressiveness occurred in all injected birds. This was followed by a development of territorial tendencies in the same individuals, accompanied by an increased development of a peck-right type of social organization. The conclusions of Shoemaker and Diebschlag, that in the shifting conditions of the birds flocks observed by them, lay the explanation of the flexible peck-dominance type, is supported by the evidence in this case. As more birds in a flock became definitely located and began aggressively to defend the regions occupied, the social structure became more fixed.

It seems clear that the injection of testosterone propionate in low ranking members of ring dove flocks increased territorialism in the flocks and contributed to an increase in the development of a peck-right type of social hierarchy.

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ZAPATERA SPOILAGE OF OLIVES*

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Zapatera, the name given to one type of spoilage, is a Spanish word meaning, "shoemaker's wife," but the literal translation of the word is "stinkfoot." Its only means of detection is by the offensive odor produced.

In an attempt to discover the cause of Zapatera spoilage a study of types of organisms found in normal and spoiled olive brine was conducted. Microscopic examinations were made of all samples, which revealed the presence of yeasts, associated with rods and cocci. The first observation was on the number of organisms in the brine. Plate counts were made on various agars in order to isolate as many different types of organisms as possible. In all tests the spoiled samples had higher counts than those considered normal.

During the investigation determinations of pH were made electrometrically. All spoiled samples with the exception of three had a pH of 4.0 or above. Normal samples were below this figure. Exposing spoiled samples to air increased the spoilage. A rapid increase in pH also occurred, and the samples became darkened. Normal samples when exposed to the air increased somewhat in pH, but showed no darkening. These results indicate that exclusion of air, and control of pH are important factors in the prevention of the spoilage.

Smyth reported a group of spore forming, aerobic, proteolytic organisms as the cause of Zapatera spoilage. Heat tests were conducted on all samples. Organisms developed from spoiled samples which had approached a pH of 7.0 or higher. Since Zapatera begins at a pH of about 4.2 to 4.3 the possibility of spore forming organisms in the solution is very remote. Vaughn later reported that non spore forming organisms caused Zapatera spoilage.

Some of the organisms isolated from the samples were inoculated into normal samples, but the spoilage was not reproduced.

Tracy and other workers reported a spoilage of olives due to organisms of the genera *Escherichia* and *Aerobacter*. This spoilage can easily be detected by the presence of gas in the samples. No gas was noticed in Zapatera spoilage, however, all samples were inoculated into lactose fermentation tubes, and observed for gas production. Gas was produced in only one sample. It has been exposed to the air for six months, and has a pH above 8.0. Therefore it may have been easily contaminated with gas producing organisms.

A "butyric" spoilage in olives caused by the butyric acid anaerobes has been described by Vaughn. A study of anaerobes that were isolated from the brine is being conducted. As yet they have not been definitely classified. There is a possibility that they are *Lactobacilli*. These organisms play an important role in the normal fermentation of olives. Therefore their presence is essential for a good, vigorous fermentation. Tests of abnormal fermentation of olives were made, by the addition of spoiled olive brine to good olives in a salt, sugar solution with the absence of lactic acid. The flora for two and one half months has consisted of large cigar shaped yeast cells, filamentous rod forms, large and short rods, and some cocci.

An attempt is being made to classify the bacteria and yeasts isolated from samples of Zapatera spoilages.

In conclusion it can be said that the exclusion of air and control of pH would probably aid the manufacturer greatly in reducing Zapatera spoilage in olives. Incidentally this type of spoilage is chiefly a concern and loss to the manufacturer for the consumer seldom finds it in packed olives. Packers would not dare risk their business by selling olives which had this spoilage because of the offensive odor.

More work can and should be done on this type of spoilage.

* Contribution from the Collegiate Section.

CHLOROPHYLL IN THE TREATMENT OF ATHLETE'S FOOT*

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Recently, in the field of chemotherapy, chlorophyll has been used experimentally in the treatment of infections, particularly in acute or chronic local suppurative lesions. Dr. Benjamin Gruskin, Director of Experimental Pathology at Temple University, suggests the theoretical explanation that the action of chlorophyll consists for the most part of increasing the resistance of cells in some physicochemical manner so that enzymatic digestion of the cell membrane by invading bacteria or their toxins is checked; and that the bacteria are inhibited from forming toxic compounds. Dr. Gruskins' success in treating various dermatological infections, including one case of Actinomycosis, suggested the possibility of successful treatment of athlete's foot caused by a fungus of the Genus Trichophyton.

Oil soluble chlorophyll in a lanolin base, and also in a liquid solvent, was used in the treatment of cases in the present study. Volunteer patients were brought to the laboratory and their feet examined, particular attention being paid to scales, pustules, open lesions and breaks in the skin. Cultures of skin scrapings and pus were made on plain agar, Sabouraud's maltose agar with and without tellurite, and a hanging drop preparation containing maltose, peptone and water. The medium containing tellurite was efficient in inhibiting the growth of certain bacteria found on the feet, so was satisfactory for the isolation of the fungi, on which it had no appreciable effect. The cultures were incubated at room temperature and Trichophyton isolated when possible. Check cultures were made in 2-3 days, and final cultures were taken after treatment had been followed for at least two weeks.

Treatment consisted of rubbing or swabbing the chlorophyll material thoroughly into and around the lesions. Each person was instructed to apply treatment once daily, and regularity in treatment was emphasized. Thirty-one cases were treated, but only one case could be reported as cured. The chlorophyll treatment, however, had some beneficial effect. There was some evidence of better results when Trichophyton was not isolated as the cause of the infection, and little or no improvement was noted in acute cases where the fungi were definitely isolated. Neither the liquid nor the ointment showed any fungistatic power with tests carried out, a fact which seem to indicate, also, that chlorophyll has no fungicidal power. This is in line with Dr. Gruskin's theory that chlorophyll increases the resistance of the cell.

In conclusion, the present experiment indicated that chlorophyll is of value in preventing cracks and itching in the interdigital spaces, but that it seldom, if ever, cures athlete's foot. Better results might be obtained if the treatment could be carefully controlled.

* Contribution from the **Collegiate Section.**

THE ANGLERS' CATCH AT LAKE CHAUTAUQUA NEAR HAVANA, ILLINOIS, WITH COMPARATIVE DATA ON HOOPNET SAMPLES

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The year 1942 was the third successive year in which a partial record was obtained of the hook-and-line catch at Lake Chautauqua, a wildlife refuge maintained by the U. S. Fish and Wildlife Service near Havana, Illinois. Lake Chautauqua is an abandoned drainage and levee district. The levees separate the refuge from the adjoining Illinois River except at flood stages. At ordinary levels the lake has an area of 3,200 acres and a maximum depth of about 5 feet. The lake is approximately 6 miles long and a mile wide.

Lake Chautauqua attracts more hook-and-line fishermen than any other lake along the Illinois River; nevertheless, the fishing cannot be ranked high. Largemouth bass, bluegills, both black and white crappies, yellow perch, and yellow bass *(Morone interrupta)* are the principal kinds caught.

The census was conducted by the Illinois Natural History Survey with the cooperation of the U. S. Fish and Wildlife Service through Mr. Homer L. Bradley, refuge manager, and Mr. Milfred Smith, refuge patrolman.

The catch records were kept by the boat liverymen, that is, by men in the business of renting rowboats. The records kept by Mr. Frank Kuntz, caretaker at Bridgeman's livery, were nearly 100 per cent complete for 1941 and 1942 and because of their completeness are especially valuable for a study of seasonal trends in fishing. Bridgeman's record alone comprises the data for the present paper.

The Bridgeman record for 1940 covered only three months and no records were kept of people who failed to catch fish.

Bridgeman's livery is located on Haven's Slough at the northeast end of Lake Chautauqua. This part of the lake is protected from wind and supports rather dense growths of submerged aquatic plants. Above Bridgeman's dock the slough widens out into an area of about 80 acres. Most of the fishermen renting boats at Bridgeman's stay within this small area. A considerable amount of still-fishing is done around dense stands of button bush, *Cephalanthus occidentalis*, which grows in water up to three feet in depth. A certain amount of still-fishing is also done in the shade of the partly submerged willows, as well as in open water. The proportion of all Chautauqua fishermen using this boat livery cannot easily be estimated. Besides the boat liveries on the lake proper, of which there were five in 1941 and two in 1942, there are two liveries at Liverpool and others at Havana. Boats from the latter towns are hauled over the levees on wooden rollers, or pull-overs. Numbers of private boats are also on the lake, but no estimate of their numbers is at hand.

The record cards were made out for parties rather than for individuals. The parties usually consisted of two persons each. The information entered on each card included number of fishermen in the party, number of hours spent, and number of each kind of fish brought to the dock. The boat yard attendants were not asked to separate the species of crappies, bullheads, or sunfish except for bluegills. No observations were made on lengths or weights.

The periods covered in this report include all of the year 1941 and from January 1 to September 6, 1942, except that no fishing was allowed during the 1941 duck shooting season, October 16–December 14. Bass fishing was closed both years from April 1 to May 31. Winter fishing was prohibited under the ice but was permitted where holes naturally remained open.

Kinds and Numbers Caught and Differences in the 1941 and 1942 Catch. — The species totals for the same periods of

1941 and 1942, i. e., January 1 to September 6, are shown in table 1. Number caught refers to the fish taken away from the lake. No record was kept of the fish thrown back. The late 1941 data are omitted from this list because of absence of corresponding data for 1942. There are certain striking differences in the catch for the two years. In 1942 there were a great many more bluegills and yellow bass with fewer crappies and fewer miscellaneous sunfish.

TABLE 1.—COMPARISON OF THE 1941 AND 1942 SEASONS WITH RESPECT TO KINDS AND NUMBERS OF FISH CAUGHT BY ANGLERS AT BRIDGEMAN'S BOAT LIVERY ON LAKE CHAUTAUQUA IN THE PERIOD JANUARY 1–SEPTEMBER 6

Kinds	1941	1942
Largemouth bass	426	450
Smallmouth bass	1	0
Bluegill	2,043	3,622
Other sunfish	400	306
Crappie	681	357
Yellow perch	1,002	1,110
Yellow bass	9	1,236
Sheepshead	55	4
Bullhead	56	75
Channel cat	13	0
Buffalo	0	1
Dogfish	3	2
Eel	0	1
Kind not shown	30	0
Total fish	4,719	7,164
Total fisherman-days	1,695	1,563
Av. catch per fisherman per day	2.8	4.6
Av. catch per fisherman per hour	0.7	1.0

Whereas only 9 yellow bass were recorded for 1941, 1,236 were recorded for 1942. Due to this increase the yellow bass ranked second in importance of all kinds caught in 1942. It is significant that the yellow bass was among the three most abundant kinds taken in hoopnet samples in 1940, 1941, and 1942, but had no importance in the hook-and-line catch until the last year. Lake Chautauqua may be considered unusual among Illinois waters for its large populations of both yellow bass and yellow perch.

Number of Zero Catches. — For the periods mentioned above, the percentage of boats returning with no fish averaged 40 per cent in 1941 and 41 per cent in 1942. During some of the poorer weeks in the middle of the summer zero catches ran as high as 50 per cent. Since there were usually in each boat two fishermen, only one of whom may have caught fish, the percentage of individuals failing to catch fish would be somewhat higher than the figures given for boats.

The Average Catch Per Fisherman-Day and Average Catch Per Hour.—For corresponding periods January 1 to September 6, the average daily catch was 2.8 fish per day in 1941 and 4.6 fish per day in 1942. The length of day averaged 4.1 hours in 1941 and 4.5 hours in 1942. The average 1941 catch, however, was larger, 3.6 fish per day, when the period September 17–December 31 is included.

The average catch per hour for the period January 1 to September 6 was 0.7 fish per hour in 1941 and 1.0 fish in 1942. For the entire 1941 season, January to December, the catch per hour was 0.9 fish.

The non-technical reader should bear in mind that these are averages of good and bad periods and of expert and inexpert fishermen. Nevertheless, the legal creel limit of 10 bass, 25 of other fine fish of a single kind, or 35 in the aggregate of several kinds, was seldom obtained or even approached except during September and October, 1941, when many limits of bluegills were taken.

The following tabulation (table 2) shows how Lake Chautauqua compares with some other lakes both within and outside the State of Illinois, in terms of number of fish caught per hour. The figures for Rinaker Lake, Onized Lake, and Lake Glendale are from unpublished data. Rinaker Lake (14.3 acres) near Carlinville, Illinois, is an artificial lake 40 years old operated by a club with 75 members. The fishing record for the years 1932-39 has been analyzed by Dr. David H. Thompson of the Illinois Natural History Survey. The fishing began in March or April each year (except in 1932 when the record began in June) and ended in October or November. The largest number of fishermen-days for any of the 8 years was 642.

Onized Lake (2 acres) near Alton, Illinois, has been under the observation of Dr. George W. Bennett, also of the Illinois Natural History Survey. The record covers two years, 1939 and 1940, and takes in the months April to October.

Lake Glendale (82 acres) is a new lake in the Shawnee National Forest in southern Illinois near Dixon Springs. The record covers 2,754 man-days during the summer of 1942, which was the first year the lake was opened to fishing. The lake was completed in 1939, and stocked in April, 1940. Fishing in 1942 was permitted from May 15 to August 29.

TABLE 2. — OBSERVED AVERAGE CATCH PER HOUR IN FOUR ILLINOIS LAKES, AND CORRESPONDING DATA FROM LAKES IN OTHER STATES

State and lake	Length of record	Fish per hour (High and low yearly average)
Illinois—		
Glendale	1 year	0.4
Onized	2 years	0.4—0.8
Rinaker	8 years	1.0—2.1
Chautauqua	2 years	0.7—1.0
Michigan—		
Fife	4 years	1.0—1.7
Waterloo Area (12 lakes)	1 year	1.2
Whitmore Lake	5 years	
Largemouth bass		0.3—1.4
Bluegill		4.4—12.8
Bullhead		1.8—3.7
Wisconsin—		
Chequamegon Forest (5 lakes)	1 year	0.8
Waubesa*	1 year	1.9
Kegonsa*	1 year	1.2
Tennessee—		
Reelfoot	1 year	1.6
Norris	2 years	0.2—0.3
Wheeler	1 year	0.4
New York—		
Chautauqua Lake	5 days (July 1-5)	0.5

* The authors thought that all zero catches were probably not reported and that these figures were somewhat too high.

On all three of the above lakes the censuses were handled by full time caretakers who were charged with the responsibility of recording the results of all fishermen.

The catch rates for out-of-state waters were obtained from the papers of Eschmeyer (1939), Hazzard and Eschmeyer (1938), Eschmeyer and Tarzwell (1941), Elkins (1937), Frey, Pedracine, and Vike (1939), Moore (1938), and Troutman (1941).

The dates at which the various censuses begin and end differ considerably so that the catch per hour figures should only be taken as suggestive of the quality of fishing in different parts of the country. An hourly rate of 2 fish per hour seems to represent unusually good fishing and 3 fish per hour very exceptional fishing. Some of the lowest yields were found among lakes in which rates ran heavily to large game fish. This was true for Norris Reservoir (Tennessee), and for two of the five lakes in Chequamegon Forest (Wisconsin).

Seasonal Trends in the Numbers of People Fishing.—Marked variation from week to week may be seen in tables 3 and 4 in numbers of people who fished at Lake Chautauqua. Both in 1941 and 1942 fishing was well under way by April, but the numbers of fishermen dropped off around the second or third week in July. Fishermen came in comparatively large numbers throughout September and into October until fishing was closed at the opening of the duck season. In 1941 the peak number of fishermen occurred during the week ending May 18 at the height of the crappie season, while in 1942 this peak occurred during the opening week of the bass season, June 1, which was also the second best week in 1941. It might be suggested that the decline in number of fishermen in July resulted from the discouragement of the bass fishermen or perhaps because the peak interest in fishing is reached by a certain group of fishermen at the opening of the bass season.

Seasonal Variation in the Anglers' Catch.—Seasonal variation in the catch per hour of the important species has been determined by dividing each week's catch by the total hours of fishing by all fishermen.

The catch-per-hour rates for weekly periods in 1941 and 1942 are shown in tables 3 and 4 and in figure 1.

On the basis of figure 1 the following conclusions are reached with respect to seasonal variations in fishing:

1. There are definite peaks in biting activity, but these peaks do not necessarily occur at the same time for all species.

2. The biting of a given species may show several conspicuous peaks during the same year.

3. The peaks may occur at quite different times in different years.

4. Periods of excellent fishing tend to be short, i.e., peaks are more inclined to have steep than gradually tapered slopes.

There was enough difference between periods of good fishing in 1941 and 1942 to make it impossible to define accurately the most likely time of the year for a good catch. The periods when fishing was better than ordinary, however, are defined below.

Largemouth bass.—Rather good catches of bass were made in January and February, 1941 (see table 2), but were not duplicated in corresponding months of

TABLE 3.—BRIDGEMAN'S LIVERY, 1941. NUMBERS OF FISH AND CATCH PER HOUR RATE BY WEEKS FOR MOST IMPORTANT SPECIES. THE CATCH PER HOUR RATE IS BASED ON TOTAL HOURS OF FISHING INCLUDING THOSE SPENT BY THE UNSUCCESSFUL FISHERMEN. THE YELLOW BASS WAS NOT ONE OF THE IMPORTANT HOOK-AND-LINE SPECIES IN 1941.

Week ending Sunday—	Number of fishermen	Total hours	Largemouth bass		Bluegill		Crappie		Yellow perch	
			Number	Catch per hour	Number	Catch per hour	Number	Catch per hour	Number	Catch per hour
Jan. 5	4	Not recorded	29	?						
" 12	6		54	?						
Feb. 16	1		7	?						
" 23	1		7	?						
Mar. 2	5		15	?	17	?				
" 9	2				14	?				
Apr. 6	23	92	Bass season closed Apr. 1 to June 1		64	0.695	5	0.054	27	0.293
" 13	69	340			194	0.570	37	0.108	207	0.608
" 20	16	64			9	0.140	3	0.046	32	0.500
" 27	71	360			61	0.169	17	0.047	111	0.308
May 4	110	460			90	0.195	138	0.300	94	0.204
" 11	38	154			17	0.110	101	0.655	37	0.240
" 18	196	965			249	0.258	167	0.173	116	0.120
" 25	101	380			199	0.523	6	0.015	18	0.047
June 1	157	700	36	0.051	258	0.368	2	0.003	21	0.030
" 8	139	486	63	0.130	45	0.092				
" 15	44	188	17	0.091	67	0.356	1	0.005	2	0.010
" 22	106	236	33	0.139	80	0.338	1	0.004	54	0.228
" 29	28	84	6	0.071						
July 6	102	374	38	0.101	33	0.088			7	0.018
" 13	80	306	32	0.104	90	0.294	35	0.114	33	0.107
" 20	101	390	15	0.038	75	0.192	20	0.051	60	0.154
" 27	24	75	7	0.093	31	0.413			7	0.093
Aug. 3	53	201	13	0.064	66	0.328			30	0.149
" 10	10	502	2	0.004	55	0.109	13	0.025	12	0.024
" 17	49	170	18	0.106	25	0.147	1	0.005	33	0.194
" 24	50	210	12	0.057	64	0.304	5	0.024	50	0.238
" 31	82	354	14	0.040	171	0.483	111	0.313	30	0.084
Sept. 7	27	117	8	0.068	79	0.675	18	0.153	21	0.179
" 14	86	437	13	0.029	219	0.501	11	0.025	77	0.176
" 21	68	313	27	0.086	171	0.546	4	0.012		
" 28	40	184	2	0.011	400	2.174	6	0.032		
Oct. 5	64	290	18	0.062	734	2.351	8	0.027	16	0.055
" 12	27	104	1	0.009	560	5.384				
Dec. 21	30	109	13	0.109	159	1.458			4	0.036
" 28	12	48			90	1.875			2	0.041

1942. There were no outstanding peaks during the summer and fall months in either year.

Crappie.—In Illinois the crappies are traditionally known as spring and fall biters. There were well defined peaks in May both years but no evidence was found for a fall peak. Perhaps the natural fall peak would come during the waterfowl season. The peak occurring in late August, 1941, was unexpected. The crappies underwent longer periods of complete biting inactivity than the other principal species.

Yellow Perch.—The peak month in 1941 was April, but in 1942 the peak occurred in late July and early August. There were four consecutive depression weeks starting late in May with exact correspondence in dates between the two years.

Yellow Bass.—The highest peak was reached in July with lesser peaks in April and June. This species practically refused to bite in 1941 so that there were no outstanding peaks.

Bluegill.—The bluegill seems to be the most erratic species in its biting of any of the five observed. The best fishing occurred in late September and early October, 1941, when during one week bluegills were taken at the rate of 5.38 fish per hour; while in 1942 there were three moderately high peaks as follows: January, late April, and late May.

Comparison between the Anglers' Catch and the Hoopnet Catch. — The species composition observed in the anglers' catch at Lake Chautauqua has been found to be different from the composition of the hoopnet catches. Inasmuch as hoopnets are used in fisheries work for forecasting hook-and-line possibilities of lakes and also for determining management needs for hook-and-line fishing, it is important to know how great these discrepancies are.

From May 6 to May 14, 1942, hoopnets were set in the 80 acres most used by the fishermen who rent boats at Bridgeman's livery. Seventeen hoopnet catches were obtained at this time with 4 one-inch mesh (square measure) nets. The percentage representation of each species in these seventeen catches is shown in table 5. Also appearing in this table are the percentages of the same species caught by hook and line at Bridgeman's during the five weeks ending May 31. The catches of 405 fishermen are included in the latter figures. The most striking differences in the percentages were found among bluegills and crappies. Bluegills made up 78.5 per cent of the anglers' catch but only 17.8 per cent of the hoopnet catch. Crappies, on the other hand, made up 12.6 per cent of the anglers' catch but 61.4 per cent of the hoopnet catch. Fairly important differences of this type were found also in connection with yellow perch, bullheads, and sunfish. Certain other species, namely carp, dogfish, sheepshead and buffalo, were slightly more abundant in the hoopnets than was yellow perch, but were not caught at all in May by anglers. However, the number of fishermen using special carp baits is slight as compared with the number using worms, minnows, or artificial baits.

It should be mentioned that an unusually high percentage, probably at least 90 per cent, of the hoopnet catch was made up of fish large enough to be eaten.

During the two weeks ending May 17, which most nearly coincide with the hoopnet collection dates near Bridgeman's, hoopnet and anglers' catches fail to agree any more closely than for the five weeks shown in table 5. The percentage representation of the four principal species taken by hook during those two weeks were as follows: bluegills 31.8%, crappie 9.5%, yellow perch 55.5%, and yellow bass 3.1%. The hoopnet percentages for this period were bluegills 17.8%, crappie 61.4%, yellow perch 0.4%, and yellow bass 1.7%.

The same sort of discrepancies appear in table 6, where all the hoopnet catches made in 1942 are compared with all available 1942 hook-and-line data from the Bridgeman livery.

The hoopnet data for 1942 include, besides the 17 catches in the vicinity of Bridgeman's at the northeast corner of the lake, an additional 19 catches obtained between May 4 and 14 at scattered points between Bridgeman's and the other end of the lake, a distance of 6 miles. Another 6 catches were taken near the southwest end of the lake July 9-11.

TABLE 4.—BRIDGEMAN'S LIVERY, 1942. NUMBERS OF FISH AND CATCH PER HOUR RATE BY WEEKS. THE CATCH PER HOUR IS BASED ON TOTAL HOURS OF FISHING INCLUDING THOSE SPENT BY THE UNSUCCESSFUL FISHERMEN.

Week ending	Number of fishermen	Total hours	Largemouth bass		Bluegill		Crappie		Yellow perch		Yellow bass	
			Number	Catch per hour	Number	Catch per hour	Number	Catch per hour	Number	Catch per hour	Number	Catch per hour
Jan. 11	6	33	11	0.336	7	0.212						
" 18	14	54	4	0.074	94	1.730			7	0.129		
" 25	17	41	2	0.048	71	1.700	3	0.072	3	0.072		
Feb. 8	10	36			49	1.340	2	0.055				
Apr. 5	15	68			73	1.060			2	0.029		
" 19	17	77			35	0.450	2	0.026	8	0.010		
" 26	43	176	Bass season closed Apr. 1 to June 1		339	1.810	13	0.074	49	0.278	67	0.381
May 3	59	197			298	1.510	4	0.020	13	0.066	24	0.124
" 10	43	180			16	0.089	15	0.083	37	0.203	5	0.028
" 17	63	250			34	0.136			50	0.200		
" 24	114	473			850	1.800	169	0.356	13	0.029	30	0.064
" 31	126	563			771	1.370	130	0.230	41	0.073		
June 7	223	1350	169	0.125	411	0.304	17	0.013	66	0.049	36	0.026
" 14	101	414	47	0.117	16	0.039			24	0.058		
" 21	122	564	48	0.085	238	0.422			174	0.310		
" 28	91	418	32	0.077	85	0.204			66	0.158	198	0.474
July 5	115	519	34	0.065	38	0.073			89	0.171	47	0.091
" 12	70	296	41	0.138	58	0.196			63	0.213	85	0.267
" 19	58	265	37	0.140	4	0.015			75	0.283	35	0.134
" 26	56	248	1	0.004	6	0.024			63	0.254	328	1.340
Aug. 2	49	208	14	0.067	30	0.144			97	0.466	155	0.745
" 9	56	270	5	0.018	48	0.178			97	0.360	122	0.450
" 16	49	227			41	0.180			38	0.167	75	0.330
" 23	18	81							15	0.186	11	0.136
" 30	11	55	1	0.018					5	0.100	10	0.184
Sept. 6	14	56	1	0.018					15	0.268	8	0.143

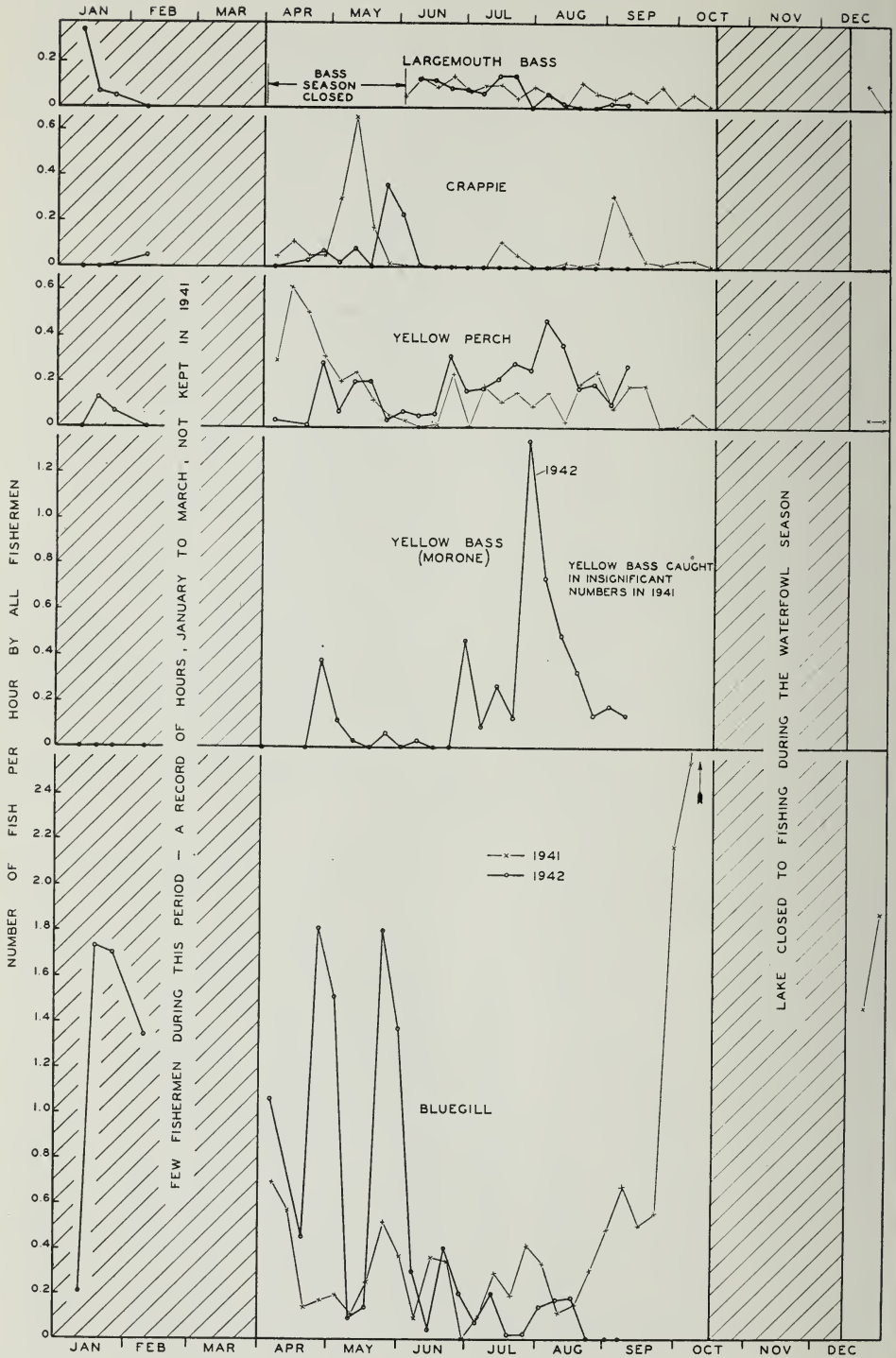

Fig. 1.—Average catch of various species per hour of fishing. Bridgeman's boat livery in 1941 and 1942. The weekly catch of each species is divided by the total hours of fishing during the week.

TABLE 5.—RELATIVE ABUNDANCE OF SPECIES IN HOOPNET CATCH AND ANGLERS' CATCH IN THE VICINITY OF BRIDGEMAN'S LIVERY DURING MAY, 1942

Species	Vicinity of Bridgeman's Livery, May, 1942			
	Angler's catch		Hoopnet catch	
	Per cent	Number	Per cent	Number
Bluegill	78.5	1969	17.8	123
Crappie (2 sp.)*	12.6	318	61.4	425
Yellow perch	6.1	154	.4	3
Yellow bass	2.4	59	1.7	12
Largemouth bass	Closed season		2.0	15
Bullhead (3 sp.)*	0.3	7	6.1	42
Other sunfish (3 sp.)*			4.3	30
Carp			3.6	25
Dogfish (Amia)		1	0.9	6
Sheepshead			0.9	6
Buffalo			0.6	4
Eel			0.3	2
Total	100.0	2,508	100.0	693

* Number of species found in hoopnets and possibly represented in the angler's catch.

TABLE 6.—RELATIVE ABUNDANCE OF SPECIES IN HOOPNET CATCH AND ANGLERS' CATCH. PERIOD OF THE ANGLERS' CATCH IN THE VICINITY OF BRIDGEMAN'S, JANUARY 1 TO SEPTEMBER 6. THE HOOPNETS WERE SET IN VARIOUS PARTS OF THE LAKE. MAY AND JULY HOOPNET CATCHES ARE COMBINED.

Species	1942 season			
	Angler's catch near Bridgeman's Jan. 1 to Sept. 6		Hoopnet catch from entire lake May and July	
	Per cent	Number	Per cent	Number
Bluegill	50.5	3,622	14.9	414
Yellow bass*	17.3	1,236	23.5	656
Yellow perch	15.5	1,110	0.7	21
Largemouth bass	6.3	450	0.8	23
Crappie	5.0	357	52.4	1,458
Other sunfish	4.3	306	2.6	72
Bullhead	1.0	75	2.7	74
Sheepshead		4		2
Dogfish (Amia)		2	0.4	11
Eel		1	0.3	8
Buffalo		1	0.2	7
Carp			1.3	35
Channel cat				1
Redhorse				1
Total	100.0	7,164	100.0	2,783

* The catch from one hoopnet set 21 hours was omitted from these totals because of the exceptionally large number of yellow bass (835) which it contained. This net also included 15 crappies and 1 or 2 individuals of other species, none of which are included in the above totals.

It is apparent that either one or both of the sampling techniques are selective. Otherwise, the percentages in tables 5 and 6 should agree. For some species, the two techniques may be selective in opposite directions. For example, bluegills may be comparatively difficult to catch in hoopnets but comparatively easy to catch on hook-and-line, thus distorting the bluegill figures with respect to those for other species. Also, the degree of selectivity for either hoopnets or hook-and-line might vary with the season of the year.

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LOCALITY RECORDS OF SOME HYDRACARINA FROM ILLINOIS

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While engaged in field work in various localities in Illinois during the summer of 1940, the writer on a few occasions incidentally collected hydracarina from the shallow water areas of rivers, lakes, and ponds. A list of the species found in these collections with an indication of the localities is given in the present paper.

Although the number of species represented in the collections is exceedingly small and most of the forms reported are known to be cosmopolitan, the writer believes that the publication of this incomplete list is justified because several species, *Neumania extendens* Marshall, *Koenikea haldemani* Viets, *Unionicola crassipes* (Müller), *Lebertia distincta* Marshall, and perhaps *Mideopsis orbicularis* (Müller), are reported herein for the first time from Illinois. What is more important, perhaps, is the finding of species which are common in the lakes of Wisconsin and northern Illinois occurring abundantly in the more or less acid waters of southern Illinois. Some of the water mites listed here were collected from waters having a hydrogen ion concentration of 6.4 to 6.6. The data are too meager to give any indication of the effect, if any, of acidity as a limiting factor in the distribution of species of hydracarina.

When the water mites of southern Illinois become better known, it may be possible to point out certain differences between the hydracarina fauna of northern and southern Illinois. That there is some difference in the invertebrate fauna of the two parts of the state is already known with respect to a few groups. It has been found that certain species of ostracods are confined to the northern part and certain ones to the southern part of the state (Hoff, 1942). To some degree, the limitation of range in this group appears to be the result of availability of certain types of habitats. Ross (1941) reported that certain species of insects are restricted to specific regions of Illinois as a result primarily of differences in vegetation. The effect of differences in vegetation upon the distribution of the aquatic invertebrates is poorly known. A detailed taxonomic and ecological study of the water mites of southern Illinois would make possible a comparison with the species of Wisconsin lakes as described by Marshall (1932, 1933, 1935, *et al.*).

The writer wishes to express his gratitude to Dr. H. J. Van Cleave for the loan from his library of much of the literature used in identifying the species reported here.

LIST OF SPECIES WITH LOCALITY RECORDS

Hydrachna sp.

1 male. Small stream, Will Co., Ill. June 30, 1940. Since the material consisted of a single male individual in which the dorsal plates could not be clearly recognized, it was not possible to determine the species.

Arrenurus marshallae Piersig

1 male. Fox Lake, Lake Co., Ill. June 29, 1940.
1 male. Bottomland lake, Whiteside Co., Ill. July 6, 1940.
1 female. Mississippi River, Rock Island Co., Ill. July 6, 1940.

Arrenurus spp.

1 female. Pistakee Bay, McHenry Co., Ill. June 29, 1940.
1 female. Lake, Vermilion Co., Ill. July 25, 1940.
1 female. Pond, Clay Co., Ill. August 15, 1940.
1 female. Pond, Massac Co., Ill. August 16, 1940.
2 females; 1 male. Pasture pond, Johnson Co., Ill. August 17, 1940.
1 female. Small lake, Lake Co., Ill. August 21, 1940. Several species are represented here but were not identified because of the lack of good male specimens.

Koenikea marshallae Viets

1 female. Mississippi River, Carroll Co., Ill. July 6, 1940.
2 males. Pond, Carroll Co., Ill. July 6, 1940.
1 male. Pond, Massac Co., Ill. August 16, 1940.
1 female. Roadside ditch, Massac Co., Ill. August 16, 1940.
1 female. Horseshoe Lake, Alexander Co., Ill. August 16, 1940.

Koenikea haldemani Viets

1 male. Pool in stream bed, Hamilton Co., Ill. August 15, 1940.
1 female. Roadside ditch, Massac Co., Ill. August 16, 1940.

Koenikea spinipes (Wolcott)

1 female. Roadside ditch, Franklin Co., Ill. August 16, 1940.

Mideopsis orbicularis (Müller)

1 female. Loon Lake, Lake Co., Ill. August 7, 1940.

Lebertia distincta Marshall

1 adult, sex not determined. West Loon Lake, Lake Co., Ill. August 7, 1940. The single individual in the hands of the writer agrees with the original description (based on a single specimen) given by Marshall (1914) except for a slight and perhaps insignificant difference in the swimming hairs of the legs and the presence of two setae rather than one on the outer (extensor) margin of the second podomere of the palp.

Limnesia fulgida Koch

(= *L. histrionica* (Hermann))

2 nymphs. Bottomland lake, Whiteside Co., Ill. July 6, 1940.
1 nymph. Mississippi River, Carroll Co., Ill. July 6, 1940.
1 nymph; 1 male. Chautauqua Lake, Mason Co., Ill. July 19, 1940.
1 female; 1 male. Pasture pond, Massac Co., Ill. June 6, 1940.
1 female. Hasting's Lake, Lake Co., Ill. August 8, 1940.
1 female; 1 male. Pasture pond, Johnson Co., Ill. August 17, 1940.

Neumania extendens Marshall

1 female; 2 nymphs. Pasture pond, Johnson Co., Ill. August 17, 1940.
1 female. Hasting's Lake, Lake Co., Ill. August 8, 1940.

Neumania sp.

Several nymphs taken in Carroll, Whiteside, Johnson, and Henry Counties, Illinois.

Unionicola crassipes (Müller)

1 female. Illinois-Mississippi Canal, Henry Co., Ill. June 13, 1940.
1 nymph. Illinois-Mississippi Canal, Bureau Co., Ill. June 13, 1940.

Piona reighardi (Wolcott)

5 nymphs. Bottomland lake, Whiteside Co., Ill. July 6, 1940.
3 nymphs; 1 female. Ox-bow, Crawford Co., Ill. June 4, 1940.
5 females. Pasture pond, Massac Co., Ill. June 6, 1940.
1 female. Pasture pond, Johnson Co., Ill. August 17, 1940.
1 nymph. Illinois River, Peoria Co., Ill. August 30, 1940.
1 young male. Mississippi River, Carroll Co., Ill. July 6, 1940.

Hygrobates longipalpis (Hermann)

1 male. Loon Lake, Lake Co., Ill. August 7, 1940.

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PSEUDO-CLEAVAGE OF THE FROG'S EGG

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During a study suggested by Dr. Waldo Shumway on the fertilization of coelomic eggs of the frog Rana pipiens, it was found that these eggs exhibited a surface phenomenon which resembled normal cleavage and is termed pseudo-cleavage. Inasmuch as the writers have found no reference of this phenomenon for amphibian eggs in the literature it has seemed proper to record its appearance in this paper.

Method.—Coelomic eggs (without jelly) were obtained by the pituitary-ovulation method of Rugh ('41). The coelomic eggs were removed after opening the body cavity and placed in a watch glass or finger bowl containing fresh sperm suspension or sperm-free salt solution. The eggs were periodically observed under binocular magnification for changes in the external appearance and for the formation of polar bodies. Observations were continued until the eggs cytolyzed or ceased to undergo surface changes. The sperm suspensions were made up in biological (chlorine-free) water. The sperm-free salt solutions used were as follows: biological water, NaCl, LiCl, frog Ringer's and Holtfreter's solution at normal and at reduced concentrations.

Experimental. — Inseminated coelomic eggs were not fertilizable and did not develop into embryos. Coelomic eggs inseminated or exposed to sperm-free salt solutions underwent cortical changes which gave an external appearance similar to cleavage planes. This phenomenon is referred to as pseudo-cleavage since cytological study showed that none of the eggs observed had complete cleavage planes which cut through the entire egg. In one case a blastomere-like segment was cut off tangentially through the upper part of the animal pole, but could not be called a true blastomere.

The order of events during the process of pseudo-cleavage were as follows. A few hours after insemination, or exposure to sperm-free salt solutions, the cytoplasm of the egg sunk away from the animal pole and became separated from the vitelline membrane which continued to maintain its original spherical shape. The space between the flattened cytoplasm and the vitelline membrane occupied, in some eggs, as much as one-fifth of the egg's diameter. Whether a fluid was present in this space was not determined. Diffusion of water or salts in solution from the surrounding medium, or dehydration of the egg cytoplasm, could supply liquid to fill this space. In some cases the first polar body was given off.

Pseudo-cleavage began as a constriction of the plasma membrane either at the center or at the periphery of the flattened cytoplasm. Deepening and increase in length of the constriction gave it the appearance of a primary cleavage furrow of the normal egg with the exception that the path of the furrow was not straight across the egg but deviated either to the right or left. In most cases secondary and tertiary furrows were formed by additional constrictions which cut off from the primary furrow or began at the periphery and met it at the center. In a few isolated cases pseudo-cleavage commenced in the animal pole near the equator of the egg, yet the cytoplasm had sunken at the apex of the animal pole.

Several hours later the egg rounded up as additional constrictions were cut off on the animal pole so that the egg appeared to have many surface blastomeres. These were of variable size and number. As many as sixteen were formed on the animal pole of one egg. These blastomere-like configurations after a few hours became flattened and the surface of the egg became relatively smooth. Cleavage furrows in most cases did not penetrate beyond the equator of the egg into the yolk material, yet the surface of the vegetal pole on some eggs was marked off with thin white lines which resembled cleavage planes. Pseudo-cleavage occurred in all of the experimental solutions except the sperm-free NaCl (it

occurred in inseminated NaCl.) The extent of pseudo-cleavage in the various salt solutions used was variable, the low concentrations producing the effect as well as the normal concentrations. The rate of pseudo-cleavage was not constant for all eggs but seemed to vary with the egg and the medium.

Discussion.—The phenomenon of pseudo-cleavage in the frog's egg probably is caused by several factors. Experimental evidence to demonstrate these factors is lacking. Osmotic pressure differences between the cytoplasm and the medium or between the cytoplasm and the liquid in the space below the vitelline membrane may cause shrinkage of the cytoplasm and consequent surface configuration. Since both normal and lowered concentrations of salt solutions caused pseudo-cleavage it may be that a permeability gradient existed which permitted a certain concentration of water, which was conducive to pseudo-cleavage, to be established in the cortex layer of the cytoplasm. From a chemical standpoint, the permeability may have permitted certain cations or anions to enter or leave the egg and cause the cortical cytoplasm to stiffen and constrict in a cleavage pattern. Calcium may well be the ion involved. The phenomenon may be an expression of an aging process. Schechter ('41) working with the unfertilized clam egg, Mactra, in sea water found that when the egg aged an indentation was formed on the egg. The surface of the egg became crumpled and polar bodies were sometimes given off. He thinks that these changes are caused by nuclear material released by the aged germinal vesicle and that the process may be an "abortive attempt at parthenogenesis before the cell dies."

Conclusions.—Coelomic eggs upon insemination or exposure to salt solutions undergo surface changes which give the external appearance of cleavage. This phenomenon is termed pseudo-cleavage.

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A CONTRIBUTION TO THE EXPLORATION OF MEXICO

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Less than thirty driving hours from this campus lies the northern border of the Republic of Mexico. Not only have Mexico's old world civilization and majestic scenery attracted thousands of awe-inspired tourists during the last few years, but its rich and varied flora and fauna have lately attracted an increasing number of biological investigators.

Early in the nineteenth century, several European explorers made classical collections in southern Mexico, and in the latter part of the century, Godman and Salvin's magnificent set of illustrated volumes, *Biologica Centrali Americana*, summarized most of the biological knowledge of Mexico and Central America existing at that day. During the last ten years of the same century, Nelson and Goldman traversed Mexico from north to south and from east to west and returned with huge collections of mammals and birds. At the same time, Cyrus Pringle was invading many parts of Mexico and returning with large botanical collections which were promptly studied and distributed among the herbaria of the world.

The knowledge gained from these expeditions was kept alive only in scientific publications, since for many years little further progress was made in the exploration of Mexico. Biologists were well aware that at our very door flourished a tropical flora and fauna as luxurient and as diverse as is to be found in almost any part of the earth. They knew, moreover, that the high central plateau of Mexico and the massive mountain ranges which border the plateau harbor plants and animals which are either the same or related to those of temperate North America, and that a thorough study of the natural history of Mexico would be necessary before many of the phenomena concerning our own animal and plant life could be adequately explained.

In recent years, this spark of interest has burst into a flame of renewed exploration and research. With closer cooperation between the scientific institution of Mexico and the United States, improved traveling facilities, and peaceful internal and international conditions, more and more American investigators have been going to Mexico for a few weeks or a few months, and even more have been engaged in the study of their collections and findings. The Mexican students themselves have been exploring their land more assiduously than heretofore, and have created several excellent journals for reporting their results and those of their American colleagues. In our own country, scarcely a single issue of many of the leading biological journals appears without one or more articles devoted in whole or part to Mexican specimens, observations, or research.

In Mexico City, in buildings furnished by the Mexican government, the U. S. Department of Agriculture maintains an excellent laboratory for study of the fruit fly. There it can determine the fly's importance should it become established in our own orchards, and suggest methods of combating it and preventing it from crossing the international border. Field laboratories in various parts of Mexico contribute additional information towards this study. Other investigators have been exploring Mexico for rare or valuable plants for breeding or cultivation, or to encourage their cultivation in Mexico for the mutual benefit of both nations. Entomologists interested in the biological control of insects have gone to Mexico in search of parasites of Mexican insects which have become important pests of our crops, for with our modern commercial activity and agricultural practices it is often simple for such inadvertently introduced insects to become economic liabilities.

If only to increase the volume of scientific knowledge, museum and university researchers have been combing Mexico for new or rare species, or to secure distributional or ecological data for those which are already known. The proximity of Mexico and the United States, together with the intergradation and interdigitation of this continent's temperate

and tropical biotic elements there, make these investigations of pertinent interest, more so than if they were done in some far-off land.

For the last four years, the speaker has taken expeditions, each involving three months of time and a staff of from five to eleven persons, into Mexico to contribute in a small measure to the increasing wealth of knowledge concerning Mexican plants and animals.

Our stopping places have been chosen, so far as possible within the limits of time and financial resources, to provide us with as adequate a conception as possible of the various biotic units that characterize the Mexican region. In the eastern lowlands we have made numerous stops between the northern scrub forests and the more humid central forests. Our first stop each year has been in the thick semi-desert scrub, similar to that of Texas, less than a hundred miles south of Laredo, and the second in a mesic, temperate forest, less than a hundred miles farther south, which greatly reminds us of some of our Illinois ravine forests. Then we have worked farther south in the various transitional forests that grade into the tropical jungles characteristic of Central America. At other times we have stopped in the mountains and traveled up and down through the various altitudinal zones, and then crossed the great divide and gone down to the high central plateau which occupies the whole central part of Mexico. Visiting these places year after year gives those of us who can make the trip again an opportunity to profit from our previous experiences there and from what we have learned during a winter of studying our notes and specimens.

The composition of our party is designed so that we may gain as complete a picture as possible of the biotic complement of each region in which we spend a few days, weeks or months. The membership of our fourth expedition consisted of two entomologists, a mammologist, a herpetologist, an ornithologist, a parasitologist, and a botanist, besides two helpers for these men. In addition, we brought our own cook to sustain them, and a native student to make many of the necessary and time-consuming arrangements. The close cooperation between the various members of the party is of mutual benefit. For instance, the ornithologist, mammologist, and herpetologist provide specimens for the parasitologist, or the latter, in turn, assists each one in obtaining animals. The botanist surveys the region, and after consultation with the others who have traveled through it in search of other specimens, announces the vegetational outlines and affinities of the locality under study. Or he cares for plants from which the entomologists have taken certain insects, so that these hosts can later be identified and the data recorded with the names of the insects. The herpetologist is sometimes so busy caring for the specimens which the others bring in in their searches that he cannot find time to go into the field himself for days at a time.

This method of procedure and organization, we believe, is an ideal way to study any new region. We have succeeded in obtaining several hundred new species of plants and animals in Mexico, and almost two dozen new genera of animals. In addition, the known range of hundreds of animals and plants have been extended, and many rare forms have been brought to the attention of students interested in them. But best of all, we have secured records of thousands of already known species of plants and animals which help us to correlate our findings with what is already known about the biogeography of Mexico. To make this information available to other students, each of our men has reports of his work in progress or in press. In addition, scores of papers by others who have studied our specimens have appeared or are in preparation or in press.

Our results after four years of effort might have been much more impressive had we had expensive equipment and ample financial backing, but with dependence mostly on collecting equipment and our own five senses for specimens and data, and with only some pecuniary assistance from Chicago's Field Museum and a few other interested colleagues, besides the limited personal ability to finance these trips, our efforts have been restricted more than we have liked. In addition, our gross inexperience and lack of guidance on the first and second trips greatly reduced our results, and it has only been with increasing experience and knowledge that we have begun to accomplish that which we first hoped to do. The loss of much of our insect collection the first year and a serious accident early

the second year greatly hampered the work, but the "breaks" on the last two trips have been as good as the early ones were bad.

Our most ambitious research problem is now in progress in the mountains at the southern end of the great Mexican plateau. We have already spent four months there in an investigation of a swath of land, or transect, some fifty miles long, which begins in a wide, sweltering river valley only a thousand feet above sea level, and progresses upward through the various transitional zones to the temperate forests at six thousand feet elevation, and then up the cold, damp slopes of the adjacent mountain to its summit at about twelve thousand feet. In an isolated village at the halfway point, seldom if ever before visited by Americans, we have made our headquarters in the many rooms of one of the town's largest adobe houses. The local people are our good friends and perform many services as we spend happy and busy weeks climbing up the mountain to its peak, just a day's journey above our house, or down to the hot lowlands, just a day's journey below our house. On the mountain, we work from base camps which are supplied by frequent visits of the expedition's mule driver and his balky animals. The middle region of this steep transect, we easily work with the house as a base, and in the lowlands we lodge with a well-educated Dane who makes our work easier with his many years of experience in that section of the country. In the lowlands, our work is speeded since we are able to bring in our truck, after a slow and treacherous drive, and dash from place to place over the hard valley floor, but in the mountains we are connected with the world only by forty miles of narrow, slippery, and winding mule paths and a single noisy telephone that operates only for one or two hours a week if we are lucky after yelling into its scratchy recesses for several hours beforehand.

After four months of work by eleven people and many retainers, we have secured the records of part of the invertebrates, many of the birds, and most of the mammals, reptiles, and amphibia which are found in this steep fifty mile stretch of Mexican mountain country. Our future plans, once the war is over and traveling for nonbelligerent purposes may be resumed, is to establish ourselves in this region for a whole year, not only to continue to study the altitudinal differences there, but also to observe the seasonal variation in the flora and fauna. Thus we hope to contribute our bit to the exploration of Mexico.

COMPARATIVE PHARMACOLOGY OF MYOGENIC AND NEUROGENIC HEARTS

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The hearts of adult vertebrates and molluscs are known to be inhibited by acetylcholine. These hearts are myogenic in that their pacemakers are muscular in nature, although the hearts may contain secondary regulating neurones. It is suggested that myogenic hearts in general may be inhibited by acetylcholine.

The hearts of decapod Crustacea, of Limulus and of the grasshopper, Melanoplus, have been shown to be accelerated by acetylcholine. Limulus, the decapod Crustacea, and probably Melanoplus have ganglionic pacemakers, i.e., are neurogenic. It is suggested that neurogenic hearts may be accelerated by acetylcholine.

Embryonic hearts (Fundulus) were shown by Armstrong (1935) to be unaffected by acetylcholine prior to vagal innervation. Apparently innervation sensitizes the heart so that it is inhibited by the drug. We have investigated the effect of acetylcholine on the heart of Limulus throughout early development. From the 21st to 32nd days when the heart is not innervated (Carlson and Meek 1908) acetylcholine is without effect. Later it is accelerated. It is suggested, therefore, that non-innervated hearts are not affected by acetylcholine.

Kymographic records were obtained of the heart beat of the annelid, Arenicola, and the hearts and dorsal vessel of Lumbricus were counted. Both these animals showed acetylcholine acceleration. Histological evidence supports the suggestion that their hearts are neurogenic.

The heart of the freshwater isopod Caecidotea is accelerated by acetylcholine. Multipolar ganglion cells have been described in the heart of the isopod, Ligia (Alexandrowicz, 1932). The hearts of two amphipods, Talorchestia and Bactrurus, and of a copepod, Diaptomus, are likewise accelerated. It is likely that they are neurogenic.

Baylor (1941) has found the heart of Daphnia to be inhibited by acetylcholine. Ingle (personal communication) has been unable to find ganglion cells in this heart.

Acetylcholine is without effect, even in high concentrations (10^{-3}) with or without eserine, on the hearts of Artemia or Eubranchippus. Pure adrenaline is also ineffective on the Atemia heart although adrenalin solution (Parke Davis) inhibits due to the reducing agent, sodium bisulphite. A variety of control experiments shows that lack of effect of acetlycholine is not due to lack of penetration into the animals. It is suggested on the basis of the Fundulus and Limulus embryo experiments that the hearts of Artemia and Eubranchippus are not innervated.

In general, potassium acts much the same as acetylcholine. Calcium antagonizes potassium by slowing the higher Crustacean and Limulus hearts but its effects on myogenic hearts are complex.

It is likely that the action of acetylcholine provides a pharmacological method for distinguishing between neurogenic, innervated myogenic, and non-innervated hearts.

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INDUCED OVULATION IN *RANA PIPIENS* III

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The relation of the pituitary gland to ovulation in amphibians has been studied since the work of Wolf in 1929. Implantations of the pituitary into the lateral or femoral lymph sac[1] and under the skin[2], and injections of pituitary suspensions into the abdominal vein,[2] dorsal lymph sac or hind leg muscles,[3] and body cavity,[4, 5, 6] have all caused ovulation. Injections of other substances besides amphibian pituitaries such as human placenta,[3] whole sheep pituitary,[4] antuitrin-S,[6] human pregnancy urine,[7, 8] progesterone,[9] testosterone and methyl testosterone,[10] have also induced more or less ovulation. These studies on the effect of various substances on the ovulation process have been complicated by the fact that the ovaries were left in the animals during the period of ovulation. A quantitative measurement of the amount of ovulation is difficult to obtain under such circumstances. The writer, in collaboration with Henry C. Hill, Jr., has shown[11, 12] that ovulation may be studied quantitatively by removing the ovaries some hours after injection of the frog and suspending them in Ringer's solution.

Recently ovulation has been obtained from ovaries which were removed from normal uninjected females and placed in Ringer's solution containing a suspension of female pituitaries. Zwarenstein[13] reported that ovulation can be induced in excised ovaries of Xenopus, suspended in Ringer's solution, by the addition of progesterone, and Shapiro and Zwarenstein[14] showed that testosterone and androstenedione are similarly effective. Experiments reported in this paper prove that ovaries from *Rana pipiens* will ovulate when placed in Ringer's solution containing *Rana pipiens* pituitaries.

Method.—Hibernating frogs received from Wisconsin were soaked in cold water and placed in a refrigerator at 0 to 1° C. until used. They were periodically removed, bathed in cold water, and returned to refrigerator. Under these conditions good ovulation was obtained in experiments covering a month's time. Pituitary glands were removed from females, placed in Ringer's solution, and broken up into a fine suspension. Various concentrations of the hormones for each experiment were prepared by dilution from such a pituitary suspension. Ovaries from the same females used for the pituitary suspension or from other females were removed and portions of these ovaries were suspended by Nichrome wires in vials containing the Ringer-pituitary suspension. Ovulation occurred in these pituitary suspensions, and by periodic counts until ovulation ceased the rate and total amount of ovulation was determined.

Experiments

1. *Effect of pituitary concentration on ovulation.*

Six experiments were performed in which the ovaries were placed in various concentrations of female pituitaries, ranging from zero to one pituitary per ml of suspension. The results of these experiments are summarized in Table I.

Only one egg was obtained in six control vials which contained the Ringer's solution but no pituitary. No eggs were found in the six vials which contained 0.001, 0.002, and 0.005 pituitary per ml. Starting with 0.01 some ovulation occurred, increased to a maximum around 0.08 and decreased to a minimum at 1.0 pituitary per ml. Experiments performed a year ago, using concentrations of several pituitaries per ml, gave no ovulation. The occurrence of a maximum effect is interesting because it shows that some inhibitory factor, which increases with concentration, must be present; and the low optimal concentration (0.08) may indicate something of the amount of pituitary normally needed in the female at the time of ovulation.

2. *Effect of methods of storage of the frogs on the subsequent ovulation.*

In a second series of experiments a new shipment of female frogs was divided

TABLE I.—EFFECT OF PITUITARY CONCENTRATION ON OVULATION CONCENTRATION IN PITUITARIES PER ML OF RINGER-PITUITARY SUSPENSION

	0	.001	.002	.005	.01	.02	.03	.04	.05	.06	.07	.08	.09.	.10	.20	.50	1.0
Average eggs per vial	0	0	0	0	12	11	23	26	15	9	25	28	13	12	8	5	5

TABLE II.—EFFECT OF TWO METHODS OF STORAGE OF FROGS ON OVULATION JAR A FROGS KEPT IN WATER; JAR B FROGS IN MOIST AIR

	Pituitaries from		Ovaries from		Pituitaries and ovaries from	
	Jar A	Jar B	Jar A	Jar B	Jar A	Jar B
Average eggs per vial	26	28	39	15	35	12

in two groups. One group of frogs was placed in a large jar (A) containing about one inch of water, the other group in a similar jar (B) containing cheese cloth saturated with water. Thus, some of the frogs (jar A) were continually in water and the others were always in a moist atmosphere, but not actually in water. Both jars of frogs were kept in the refrigerator at 0 to 1° C. Four combinations of pituitary suspensions and ovaries were made. Ovaries from jar A frogs were tested in suspensions of pituitaries from both jar A and jar B frogs and similarly for the ovaries of jar B frogs. In all cases the suspensions were made up to a concentration of 0.08 pituitary per ml. The results are summarized in Table II.

The pituitaries of both sets of frogs were equally potent when tested on ovaries of either set; but the response from ovaries of frogs kept in water (jar A) was nearly three times as great (39 to 15 eggs) as that from ovaries of frogs kept in moist air. Successive experiments showed that the response from jar B ovaries became progressively weaker with time.

When the combination of jar A pituitaries plus ovaries is compared with that of jar B pituitaries plus ovaries it is seen that the jar A combination is about three times better than that of jar B. This difference, as could be inferred from the above paragraph, is due nearly entirely to the decreased response of the jar B ovaries and not to the decreased potency of the jar B pituitaries.

3. *Effect of pH on ovulation.*

Measurements of the pH of the pituitary solutions at the end of each experiment gave values averaging around 5.5. Preliminary experiments with buffer solutions showed that good ovulation can be obtained in buffer solutions with pH values around 5.5.

Summary.—1. Excised ovaries from normal female frogs *(Rana pipiens)* will ovulate when placed in Ringer's solution containing pituitaries from *Rana pipiens* frogs. **2.** Under the experimental conditions employed it was found that:

a. No ovulation occurred in suspensions of zero, 0.001, 0.002, and 0.005 pituitaries per ml. *b.* Maximum ovulation occurred at about 0.08 pituitary per ml. *c.* Little or no ovulation occurred in suspensions of one of more pituitaries per ml. *d.* In 0.08 pituitary per ml. suspensions good ovulation occurred at pH values around 5.5.

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CYCLOCEPHALA ABRUPTA IN ILLINOIS (COLEOP.: SCARAB.)

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To naturalists the sand areas of this state have long been the objects of great interest because some of the plant and animal inhabitants of such regions are more or less restricted to sand. Furthermore, many of these organisms seem to be of western origin. As Vestal (1913) has pointed out, "many animals reach the eastern limit of their range in the Illinois sand areas. Others are not continuous in distribution, but occur in the sand areas and also in the West." This note is concerned with what is apparently an example of the latter type of distribution pattern.

In 1907 Hart and Gleason reported on a study of the sand area around Havana, listing many western plants and animals. Hart demonstrated the western derivation of much of the insect fauna, with special emphasis on the Orthoptera. Ross (1934) has since briefly discussed that order in relation to all the sand areas of the state.

The presence of a western termite, *Reticulitermes tibialis* Banks, has been reported by Dietz (1924) from a sandy region in southwestern Indiana, and Park (1929) records the same species from the dunes of the northwestern part of that state. It also has been taken in the sandy region near St. Anne, Illinois.

More recently Knight (1941) has given an interesting record of a plant bug, *Largidea grossa* Van Duzee, from Havana. Previously this species had been reported only from California, Oregon and Arizona.

On the evening of July 21, 1941, I collected a number of specimens of a *Cyclocephala* which were flying to the lights at the Natural History Survey Field Laboratory near Havana. Through the interest of Dr. M. W. Sanderson these were identified by Mr. L. W. Saylor

Fig. 1.—Cyclocephala abrupta (Casey), male and female (enlarged).

as *Cyclocephala abrupta* (Casey), fig. 1. The record of this species from Illinois is unusual since previously it has been reported only from California, Arizona and Oregon (Saylor, 1937). The similarity between the known distribution of this little scarab and that of *Largidea grossa* is striking.

It is intriguing to speculate as to how many more species of western insects range into the sand areas of Illinois and thus far have escaped notice.

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PRECAVAL ANOMALIES OF THE CAT

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The usual or normal precava of the cat is formed by the junction of the right and left innominate veins each of which receives an internal and an external jugular and a subclavian. Veins of an adult cat in which the innominates failed to join are described early in this paper, and later, attention is given to a specimen in which the coronary sinus empties into the precava.

In the first variation considered the innominates have not joined and the left descending vein follows the coronary groove around the dorsal aspect of the heart to enter the right atrium posterior to the entrance of the post cava. This is the usual location of the entrance of the coronary sinus. The ventricular myocardium is drained by several venous branches which empty into the anomalous structure. There were also a few venous twigs which drained directly into the atrium. The atypical vein appears to represent the left innominate and the coronary sinus which have remained connected. The variation therefore is a persistent anterior and common cardinal. The anastomosis which normally occurs across the anterior cardinals cephalad to the heart failed to appear in the present instance and embryonic channels remain as the adult, functional, veins. No other significant difference is present. The right side is typical with both the azygous and sternal veins present as branches entering the right precava, or in the present case, the right anterior and common cardinal veins. This latter vein enters the right atrium in the same locality characteristic of the normal mammalian anterior vena cava.

Another adult cat possessed an unique vein which drained the blood from the ventricular myocardium into the otherwise normal anterior vena cava. This vein entered the dorsal aspect of the precava two centimeters posterior to the innominate junction. It drained almost the entire area of ventricular myocardium except for a few anastomosing twigs which emptied directly into the atrium. There was no coronary sinus entrance into the atrium. It is suggested that the peculiarly located vein draining the heart is the posterior portion of the anterior cardinal with the common cardinal. Again, the variant seems to be a persistent embryonic condition. When the right and left precaval veins (anterior cardinals) anastomosed, to form the single vessel which empties into the right atrium, the left vessel posterior to the anastomosis failed to degenerate and remained as a functional vessel. It is not certain what happened to the cardiac end of the common cardinal. It may have become occluded in the changes of the developing sinus and atrium or it may have never been open into the sinus venosus.

It is very probable that in the development of the anterior vena cava any significant variation is a retention of embryologic features. This fact has already been pointed out in connection with the post cava.

COLOR DISCRIMINATION IN CANARIES*

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Introduction.—It is a common belief that lower animals lack the ability to discriminate between colors. Such an assumption seemed to be unfounded for most of the species studied and therefore indicated the need for testing many more forms. Among birds the chicken, pigeon, ring dove, and shell parakeet have been tested and all showed color discrimination. Among Passeriformes, the English sparrow and cow-bird were tested with colored papers but these methods have since been proved inadequate due to intensity factors.

The author, in a previous experiment, had trained canaries to discriminate between a red and a green filter, thus offering the opportunity to discover whether these birds were responding to differences in the intensities transmitted or to the wave lengths.

Materials and Methods.—A "two-choice" problem box 15 inches high, 42 inches long, and 28 inches wide (Fig. 1), was constructed of plywood. Red and green Wratten A and C Monochromatic light filters mounted as lantern slides were placed over round openings in the end of the maze before the 25W lamps at E_1 and E_2. Overhead lights illuminated the box through a screen wire roof. The birds were transferred from the home cage to small individual cages. Each bird in turn was introduced at the entrance A, went through runway B toward the colored lights. At the open sliding doors, C_1 and C_2, it had to make a choice of going into alley D_1 or D_2. If the bird entered the alley illuminated by the color to which it was being trained to go it was allowed to pass on out into the exit alley F_1 or F_2, through the open door G_1 or G_2, into the return runway H_1 or H_2, and into the home cage. But when the bird was being trained to green and the green filter was at E_2 with the red at E_1, the bird made an error and entered D_1, the door C_1 was immediately closed. For this trial the door G_1 had been closed and the bird ran back and forth in D_1 and F_1 for one minute as penalty for making the incorrect choice. At the end of the minute door C_1 was opened long enough to let the bird back into B and then closed. It then passed through D_2, F_2, out the open G_2, and back to the home cage through H_2. Thus only one error could be made at a trial.

Getting out of the foreign problem box where all visual contact with its fellows was cut off and returning to the home cage to which it was accustomed provided sufficient motivation for rapid learning. The birds usually showed considerable learning in 20 – 30 trials though they continued to improve for variable lengths of time. The birds became trained to either red or green without any apparent aversion to either color. There was a strong tendency shown to go always to the same side regardless of the signal color unless penalties are begun at the outset. This rendered color "preference" experiments meaningless here as was shown in an earlier series.

In order to avoid the one side habit the birds were forced to go out to the right the same number of times as the left according to the pattern LRLLRLRRLR, etc. Even this pattern was altered often enough to show that they had not learned it but were responding to the signal light. The 6 birds reported upon here were all trained to green in a red-green combination and were given 162 trials with 25W lamps behind each filter. By that time they were making an average of only one error in 17 trials.

Color discrimination test. — The next step was to run a series of 28 trials for each bird (168 total) with the light intensity made very unequal behind the filters. This was accomplished by using a 200W in combination with a 25W lamp. The 200W lamp was moved from right to left according to the pattern RLRLRL, etc. Thus the more intense

* The assistance of Barbara Weil and Eugene Lipner is gratefully acknowledged.

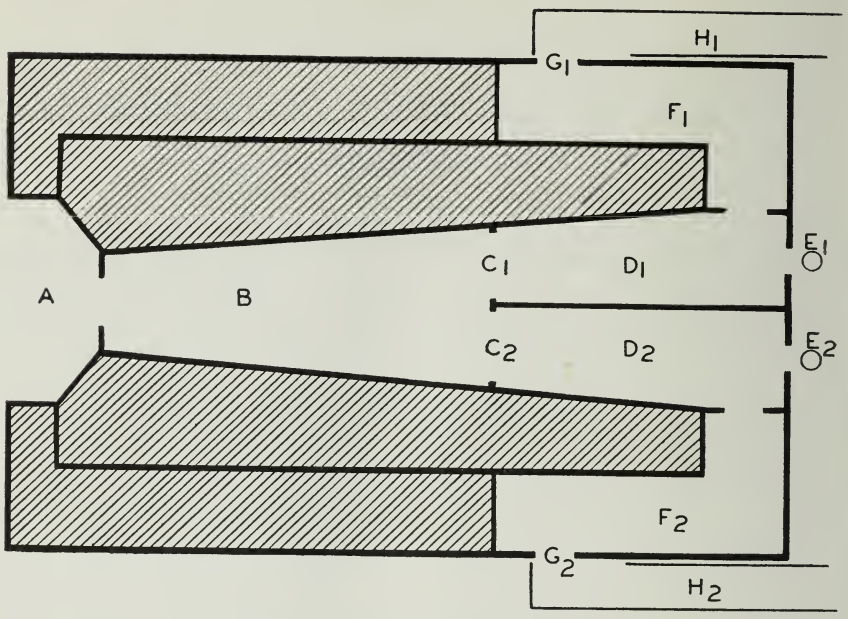

Fig. 1.—Two-choice problem box.

light fell behind the two colors an equal number of times. Though it is known that colors have varying intensity values for different species the great inequality in the light sources would counteract them.

The number of errors made in this series of 168 trials (Table I) was 10 which happened to be the same number as was made in the preceding 168 trials. The average time consumed (Table II) was slightly greater as might be expected after altering the customary conditions.

Table I.—Number of Errors in "Two-Choice" Problem Box

Bird	Errors Per 7 Trials: 25W & 25W Lamps				200W & 25W Lamps			
109-R	0	0	0	1	0	0	0	0
233-T	0	0	1	0	0	1	0	0
111-C	1	1	0	0	1	0	1	0
115-H	0	0	0	0	1	1	0	1
238-B	0	1	1	1	1	1	0	0
216-L	1	1	1	0	0	2	0	0
	2	3	3	2	3	5	1	1

Table II.—Time Required in "Two-Choice" Problem Box With One-Minute Penalties Deducted

Bird	Average Time in Seconds For 7 Trials: 25W & 25W Lamps				200W & 25W Lamps			
109-R	6.3	6.3	6.1	8.8	8.8	8.3	10.1	8.6
233-T	4.4	6.4	6.0	4.1	6.0	4.8	4.4	4.6
111-C	14.0	8.3	7.3	7.6	11.8	9.6	9.4	8.6
115-H	10.6	11.6	21.8	13.7	22.6	25.0	18.6	17.7
238-B	5.0	6.1	5.6	6.7	5.0	5.4	4.3	4.6
216-L	4.8	4.3	4.7	6.0	5.6	7.8	5.1	4.3
Ave.	7.5	7.1	8.6	7.8	9.8	10.1	8.6	8.6

For further evidence that the response was to color, one or the other of the light sources E_1 or E_2 was turned off. The green trained birds continued going to green in the absence of red or continued to avoid red in the absence of green. A red trained bird under the same conditions continued to the red in the absence of green and avoided green in the absence of red. Further tests were made with one or the other of the filter slides completely removed allowing the white light to show from behind and similar results were obtained.

Conclusions.—Canaries learned to discriminate between red and green light as transmitted through Wratten tricolor light filters A and B. No matter how much the intensities were varied with even one or the other light source entirely removed the birds continued positive to the color to which they had been trained and negative to the one which they were trained to avoid.

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STIMULATING AN INTEREST IN THE HISTORY OF THE BIOLOGICAL SCIENCES

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There is a spreading wave of interest in the history of the natural sciences. This is particularly observed in medicine but is apparent in all branches of science.

The student of science today possesses a rich heritage. The biological sciences have furnished no small part in the accumulation of this legacy. From the earliest times up to the present, they have played an integral and fundamental role in the progress of civilization. The history of biology and the history of medicine are so closely related that it is difficult to separate one from the other.

Dr. George W. Corner in his book on the history of anatomy remarks that "whether we feel it thus keenly or not, however, the influence of the past inevitably guides our hands as we work, for not only in the ancient seats of the science of anatomy, but in the newest schools of America, the methods we use, the names we learn, the present trends of our investigation have been determined by our predecessors; unless we understand them we can hardly understand our own tasks."[1]

Students in the biological sciences are naturally interested in the relationship of these sciences to man himself. This is especially true if the student is enrolled in a pre-medical course. Even if he is not in that group, the interest shown by all people in their own health and the well-being of their fellow-men makes a study of the history of the biological sciences an important contribution to one's general education.

To present a systematic series of lectures on the history of the biological sciences takes time away from the already crowded schedule of laboratory studies which are exceedingly essential. Other means of stimulating an interest in biological history are available. Such methods have proved helpful in the experience of those who have used them. These include: (1) introductory lectures and frequent, brief references to history as it relates to the subject which is being presented; (2) the use of a bulletin board devoted to the history of biology; (3) the encouragement of the reading of biographies and histories related to biological science; (4) the formation of a society of students interested in problems in history.

The introductory lecture to a course serves as an excellent opportunity to obtain a "bird's-eye" view over the entire field of the subject. The historical approach can be appropriately used at this time. William Hunter (1718-1783), founder of the Great Windmill Street School of Anatomy which played a very significant part in the history of medicine and who was one of the greatest of the teachers of anatomy, regularly began his course of lectures with an account of anatomical study from the days of Aristotle and Galen to his own period.

Reference to history can very easily be made at appropriate places. In a lecture on circulation in a general college course or in a pre-medical course, there is an opportunity to mention William Harvey and his classic of 1628, *Exercitatio Anatomica De Motu Cordis et Sanguinis in Animalibus.* Some students might be stimulated to read this book which surely belongs among those books which should be familiar to every well-read man. Appropriate reference can be made to Aristotle's *Historia Animalium* and to Harvey's *Exercitationes De Generatione Animalium* in courses in college embryology. Perhaps copies of these works can be displayed. The opportunities to inculcate an interest in the history of biological science in such a way are numerous and varied.

A bulletin board which is regularly set apart for the history of biology is a means of stimulating interest. It should be located in the laboratory in a place where the light is good and where it is easily accessible for the students. In our Gross Anatomy laboratory we found such a place. We have had occasion during the past six years to observe how carefully the bulletin board is studied. The comments by the students and the questions which have arisen in their minds—for which they have sought further information—have more than justified the time spent in preparing the exhibits.

The bulletin board is changed each week. When the student learns that new material is placed weekly on the board he will develop the habit of looking for the display. Material for the exhibits is easy to obtain. Envelopes which contain the pictures, maps and cards bearing the necessary data for each one can be filed ready for use another time. Every year brings new material. No small number of our pictures have been found in the advertisements of scientific companies and in the advertising section of scientific journals. This is especially true of material which is useful for an exhibit on medical history. Photographs in books and pictures of the title-pages of certain biological classics are easily procured. We have found that our medical students watch for material of this sort. Some of our finest illustrative material has come from them.

The student is given a mimeographed list of the bulletin board exhibits for the course on the first day the class meets. Brief biographical notes concerning the men whose photographs are included in the displays, and a bibliography of readily accessible and interesting references are included with the list. The schedule of the subjects is never the same for any two years. A cluttered, crowded board does not invite the student's attention. An attractive display of only a small amount of pertinent material is far preferable. The bulletin board must be carefully arranged.

The exhibit on Galen will serve as an example. A card with the word "Galen" and the dates of his birth and death is placed at the upper, middle part of the board. Photographs of Athens and Rome (two cities with which he was especially identified) flank the title card on either side. Beneath the card is a portrait of a bust of Galen taken from an advertisement in a journal. A map of the Mediterranean region occupies the center of the display. Pergamum is marked with red ink and a red string leads out to a card which is inscribed with the words, "Galen was born at Pergamum and was the son of the architect and mathematician, Nikon. From 157-161 A. D. he was surgeon to the gladiators of that city." Next to the card is an illustration of a gladiatorial combat from a text-book of ancient history. Smyrna, Corinth, Alexandria, Rome and Athens are similarly marked on the map and colored strings lead to cards which bear pertinent data. The left, lower corner of the board has a page from a translation of his "Anatomical Procedures," and the right, lower corner has a card on which is a brief summary of Galen's contributions as a teacher, an author and a physician.

No two persons would ever choose the same material for a bulletin board in the history of biological science. The schedule given here is only a suggestion

as to the large amount of history which can be covered in this way by having each week an exhibit of material which relates to one or more of the outstanding biologists of history.

SCHEDULE OF BULLETIN BOARD DISPLAYS

1. Aristotle (384-322 B.C.)
2. Pliny the Elder (23-79 A.D.)
3. Galen (131-201)
4. Avicenna (980-1037) and the Arabians
5. Leonardo da Vinci (1452-1519)
6. Vesalius (1514-64)
7. Gesner (1516-65)
8. Harvey (1578-1657)
9. Malpighi (1628-94)
10. Leeuwenhoek (1632-1723)
11. Linnaeus (1707-78)
12. John Hunter (1728-93) and His Associates
13. Cuvier (1769-1832)
14. Schleiden (1804-81) and Schwann (1810-82)
15. Mendel (1822-84)
16. Pasteur (1822-95)
17. Walter Reed (1851-1902) and Yellow Fever
18. Biologists of the Twentieth Century

A shelf of books in the history of the biological sciences is a constant invitation to the student to enter and enjoy the realm of literature of this sort. Books should be located on an open shelf where they may be examined at leisure. Locy's "The Story of Biology" and his "Biology and Its Makers," Singer's "Greek Science and Modern Science," J. Arthur Thomson's "The Science of Life" and "Garrison's "History of Medicine" are only a few examples of general books. Biographies have led many students to a real interest in the history of science. The excellent biography of Osler by Harvey Cushing and the one by Ethel Giddings Reid, Sigerist's "The Great Doctors," Paget's "John Hunter, Man of Science and Surgeon," D'Arcy Powers' "William Harvey" and Foster's "Claude Bernard" are of this group. Paul De Kruif's books have led several college students whom I know to an interest in the history of medical science. An exhibit of carefully chosen books in the laboratory or the lecture-room, as well as in the library, serves to direct attention to them in a forceful way.

Students are gregarious and a society for the history of biology will appeal to many of them. This organization should be properly supervised, but the students themselves should assume the duties which are required and take the leading role in its activities. The preparation and delivery of papers, the participation in discussions and the training in the conduct of meetings is most worthwhile.

These are only a few suggestions as to how we can stimulate an interest in the history of the biological sciences. Locy says that "the place of biology in public esteem and public consideration is well established." The time is here for us to lay more emphasis upon the main scenes and the chief actors in the intriguing drama of biological history.

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ZOOLOGICAL COURSES IN THE EARLY DAYS OF THE UNIVERSITY OF ILLINOIS

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In a little less than a year the University of Illinois will have passed the three quarter century mark in its history. When its doors were opened, in March 1868, to receive the first students, the offerings of courses in science were naturally considerably different from what we have come to regard as characteristic courses today. Some of the changes in course offerings have been due to changes and development of the fields of knowledge while just as truly in part they are attributable to changes in objectives.

The work in zoology in the University of Illinois falls very readily into four distinct epochs.

1. The g e s t a t i o n period from the founding in 1868 to 1885 in a struggling new institution.

2. The birth and rapid development of teaching and research under the guiding genius of Stephen A. Forbes (1885-1909).

3. The period of maturing and expanding of the scope of the department under the leadership of Henry B. Ward (1909-1933).

4. The current phase of the development of the physiological aspects of zoology which became particularly recognized in the program in 1933.

In the present article only the first two of these epochs will be considered.

In the minds of its founders, definite plans for the University were carefully formulated before it came into existence. As engendered in the mind of Jonathan B. Turner, the plan envisioned an institution dedicated to the needs of the industrial workers of the state. This idea was carried out in the charter of the University which bore the name of the "Illinois Industrial University" but the first board of trustees broadened the concept of "industrial" sufficiently to include several distinctly liberal fields of instruction in the first program of the University, even though only five faculty members were available to do all the teaching.

However, the spirit of the practical pervaded the whole institution and under these circumstances it is not surprising to find that the earliest courses in zoology and entomology were particularly concerned with matters pertaining to agriculture. One other important influence supplemented the agricultural emphasis, namely, the active interest in exploration of the West.

In the earliest plans for a University, a special committee outlined a series of desirable professorships which in scope looked very ambitious for a university starting from nothing. In a carefully guarded statement supplementing the proposed list of professorships (1867) it was added "The number of professors must depend upon the extent of the endowments and the consequent ability to pay salaries." And furthermore "Several of these departments may at the outset be represented by the same man." In the compromise between the ideal set up of separate departments and the practical problems of finance, the entire field of natural history and geology were combined and to this post Major J. W. Powell of Normal who was becoming distinguished by his western explorations was called but never became a resident teacher.

In the first year of operation of the University the Board of Trustees envisioned researches in economic zoology as a desirable field for development, but such work had already been firmly established at Normal, under the agencies of the State Entomologist and the State Natural History Society which later became the State Laboratory of Natural History. It was not until 1884, when Stephen A. Forbes, in charge of these two state organizations at Normal was persuaded to come to Urbana as professor of zoology and entomology that the University acquired the prestige which these scientific organizations had gained in the fields of economic zoology and entomology.

In the first year (Catalogue for 1868-9) the courses in zoology are rather sketchily

described. Elementary zoology, given in the second year, opened in the first term with "Principles of Zoology — development, structure, classification and distribution of animals."

The second term was devoted to "Systematic zoology, in lectures; natural orders, families, etc.; embryology, and peculiar modes of reproduction; alternate generations; comparative anatomy as applied to classification; collection and preservation of specimens and natural history of domestic animals."

In the third term was given: "Entomology; classification of insects, habits of those injurious to the region with means of checking their ravages. Habits of beneficial insects."

The first term of the third year was devoted to "general physiology, comparative anatomy and veterinary surgery."

Little is known of the methods of instruction in this first year, or of the faculty except that Professor Burrill, whose name is more familiar as a botanist, taught entomology and at least part of the zoology. He held the title of Assistant Professor of Natural Science. Professor Forbes and Dr. L. O. Howard have been outspoken in their praise of the significance of his teaching.

The objectives of natural history instruction in these early days are summed up (1873-4, catalogue and circular, p. 37) in the statement of the objects of The School of Natural History in the following sentence: "The aim of this School is to thoroughly educate and prepare Practical Geologists, Collectors and Curators of cabinets and museums of Natural History, and Superintendents of scientific explorations and surveys." It was further recorded that "The instruction is given by lectures and text-books and excursions are made under charge of the professors." Laboratory work was very limited. Late in this period it is recorded that a course in anatomy for veterinary students was taught, using a papier-mache model of a horse for laboratory study.

Until 1885, the teaching of natural science followed much the same trend as that established when the University was founded, with the objectives little changed from those mentioned above. The year 1885 marks the opening of a new epoch in the teaching of zoology and entomology in this institution. On January 1 of that year Stephen Alfred Forbes came to have charge of Entomology and Zoology after having been appointed the preceding March. Under his guidance the teaching of zoology was reorganized on new levels.

For a time he did all the teaching except for what help he commandeered from the other scientific laboratories under his direction. Under his capable direction zoology was no longer to remain a discipline intended wholly for training farmers and potential explorers, but became a professional field for intensive cultivation in laboratory study and in research.

When he first organized the laboratory teaching, Professor Forbes wrote out in longhand detailed copy for laboratory directions which were then duplicated by the blueprint process. Later editions of these guides were typewritten and duplicated by a hectograph process. A copy of this later edition was on display in the University exhibit at the Chicago World's Fair in 1893.

When Frank Smith came to the University, he introduced to the work of the elementary course exercises in the study of Protozoa and in preparation of microscopic sections. Modifications of these outlines were used down to 1909 when the courses of the department were entirely reorganized.

Previous to the coming of Forbes, zoology and entomology had been taught by individuals who had their chief interests in other fields, with no individual devoting his entire time to teaching of zoological subjects. As a start in building a staff, Professor Forbes out of his own meagre salary paid for a laboratory assistant. From this beginning, the staff was built to include specialists in various fields. Joint employment by the State Laboratory and the University enabled the building much more rapidly than could have been accomplished otherwise. Offerings in physiology, aquatic biology, experimental zoology, and ecology brought expansion to the originally humble beginnings. By 1909, when Professor Forbes retired as head of the Department of Zoology, he left to the third epoch a strong staff representing most of the fields of zoology then recognized.

The history since 1909 parallels the history of the development of new fields and is too recent to merit special attention here.

INTERRELATIONS OF INSECT-EATING INSECTS

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Scope of Entomophagy. Sweetman has found published records showing that 224 insect families, distributed among 15 of the 25 insect orders, contain species already known to live more or less by eating relatives of their own class. I estimate that about 100,000 of the million species of insects catalogued to date possess structural or physiological adaptations fitting them to make such use of their kin. These adaptive modifications for entomophagy find full opportunity for expression in the amazing variety of form and mode of life exhibited by the prolific and ubiquitous insects in their several metamorphic stages. Grubs in soil are hunted by fossorial predatory and parasitic wasps; caterpillars excavating herbaceous and woody plants are reached by the boring ovipositors and supersenses of ichneumonids; eggs, whether laid on exposed surfaces or in prepared crevices, are penetrated by the piercing mechanism of numerous microscopic serphids and chalcids, some of which even use wings as oars to swim in water where the host eggs occur; the malodorous nymphs and adults of bugs afford no defense against the ovipositors or larvipositors of tachinid flies, and neither the jumping nymphs of grasshoppers or the flying, hard-shelled adult of beetles are immune from parasitization by sarcophagid and other dipterous parasites. This small series of instances serves to show that insects, regardless of developmental stage, place of residence, mode of defense and manner of locomotion, are sought out and devoured, either at once or by small degrees over a period of time, by some entomophagous hexapod possessed of equally effective means for overcoming the defensive positions or structures of some relative. However, it would be worth while, if space permitted, to consider whether the predatory and parasitic ten per cent are actually equipped with the variety of senses and structures necessary to reach and employ as sources of nutriment all the bionomic types occurring among the non-entomophagous nine-tenths of the insect class.

Predatism and Parasitism. The relations entomophagous insects sustain to their non-entomophagous kin naturally form two classes, predatism and parasitism. Both these expressions of entomophagy are richly exemplified, and excepting some annoying borderline cases, are readily distinguished by the features presented in the following characterizations.

Predatism appears in both the major insect subclasses, Heterometabola and Holometabola. In the former, both the nymphal and adult stages are predatory, if either is so, and in the latter either the larval or adult stages, or, in some groups, both, practice predatism. The predator is mostly larger than the prey it devours or sucks out, but those equipped with grasping and inactivating devices of unusual efficiency commonly overcome insects of more bulk than themselves. In either case, the prey is killed quite promptly after seizure, and more or less consumed during the time that follows immediately. Inactivation is achieved by stinging, injection of a deadly digestive secretion through the mouth parts, or by simple mechanical biting with chewing jaws. While not a few are fitted for watchful and patient waiting until prey comes into reach of legs or mouth parts, the majority use legs and/or wings to hunt aggressively. This locomobility brings the predator over a wide terrain and hence in contact with a numerically high average diversity of prey forms and helps to account for its utilization of a different captive at each meal. Where the adult, as well as the young, is predacious, its faculties for locomotion result also in the wide distribution of the egg progeny,— as a consequence the predatory nymph and larva may hatch more or less remote from the essential prey food. This imposes on them the obligation to hunt for the living insect to be victimized and ingested.

Parasitism, on the other hand, expresses itself only in the Holometabola, and with few questionable exceptions, the feeding-growing larvae alone are parasitic entomophags. Many adult female ichneumonid, chalcidoid, sphecoid and vespoid Hymenoptera, and a few true flies feed on the individuals of the species used as a host by the larva, or even on one not so used, but since these do not confine themselves to any one individual and live there only irregularly, this relation is more akin to predatism than to parasitism. The parasitic larva, particularly early in its development, is smaller than the stage of the insect it employs as a host. And because it generally avoids feeding on the vital viscera but utilizes at first only such reserve materials as nutriment in the blood or fat body, the parasite usually permits the host to live as long as, or even somewhat longer than itself, thereby assuring itself with a food supply adequate to complete its parasitic life. In a few known cases the host dies early, hence the parasite becomes obliged to feed in its later phase in a scavengerous capacity. Many adult parasitic Hymenoptera, exclusive of the true wasps, paralyze the host by stinging. Here the size differential between parasitic and host stages is such that the latter provides the food bulk needed by the former despite cessation of its growth due to inactivation. Adult parents of the parasitic larvae resemble the parental predators in their locomobility, but are generally selective, not promiscuous in their choice of hosts for reception of the egg or larva. This comparative selectivity seems to be determined on the one hand by such inherited specialized mechanisms as sensory organs and ovipositors, and on the other by the structural, physiological and bionomic limiting factors of the hosts or their habitats. This is equivalent to stating that the larva has little to do with host selection, hence, in the case of polyphagous species, the parasite seems to be adjustable to diverse hosts. Because the parasitic larva is mostly legless from hatching to maturity, its placement on the hosts by the parent is obviously essential to survival. But this principle does not apply to the considerable number of species whose first larval instars are active planidia or triungulins. However, also, these undergo a degenerative metamorphosis that leaves them increasingly sessile and helpless after the first molt.

Forms of Parasitism. Parasitism seems to assume a greater variety of forms than predatism, hence also a greater diversity of relations to their food species. The principal relations or forms have been fairly well defined to date, but numerous further variations of these are readily found among the species whose bionomics have been investigated. The chief relations are distinguished on the basis of the position the parasite assumes with reference to the host, the number of parasitic individuals or species attacking a host, and the relation of the several parasites to each other.

First, classified as to position, the larvae are ectoparasitic or endoparasitic. Although the large majority attack the host exclusively either from without or from within, a few species initiate the attack externally and terminate their development as endoparasites, and a few cases of the reverse relation have been recorded.

Second, entomophagous parasitism is solitary when but one individual attacks one host, but gregarious or supernumerary when two or more parasitic larvae attack one host simultaneously and sustain like, i.e., parallel relations to it. Gregariousness may involve a number of larvae of a single species,—a relation termed superparasitism, or the number may represent two, and possibly more, species,—a condition described as multiparasitism.

Third, where several parasitic species are associated with one host, but sustain a successive instead of a simultaneous relation to it, each successively attacking its immediate predecessor, a relation known as hyperparasitism exists. Here the primary or non-parasitic host (e.g. a leaf-eating caterpillar) is first attacked by the primary parasite (e.g. an ichneumonid); the latter, in turn is utilized as a source of food by a secondary parasite (e.g. a chalcid), thus becoming the secondary host. Hyperparasitism of the secondary degree is richly exemplified among the ichneumonid and chalcid Hymenoptera, but well demonstrated instances of tertiary parasitism seem to be infrequent. In a few cases (e.g. the chalcid *Dibrachys cavus*), the species work at one time as a primary and at another as a secondary parasite.

Fourth, since only the larvae and not the adults of Holometabola are entomophagous parasites, the parasitism described here is exclusively transitory in character; no absolute parasitism, in which all the life stages live entomophagously on or in the host, occurs. The nearest approach to the permanent relation appears in certain Scelionidae whose adults ride the adult host, thereby facilitating oviposition in the host egg. But these phoric adult forms are not known to derive their food from the parent host, hence do not constitute entomophagous parasites.

Fifth, entomophagous parasitic insects vary greatly from facultative to obligatory from the standpoint of their dependence on the host. A few seem to be limited to one stage of one species, others to a few of close taxomic relationship or of similar modes of life or habitats, whereas a large number exhibit a wider adaptability and utilize hosts of more varied taxonomy and bionomics. These several degrees of dependence may be expressed as monophagous, oligophagous and polyphagous. Predators are largely polyphagous, but some forms that stand close to the borderline between predatism and parasitism are restricted to few prey species (e.g. blister beetles predatory exclusively in the egg masses of locusts).

Phoresy. This relation, in which one species utilizes another as a carrier but not as a direct source of food, serves merely to facilitate parasitism and does not in itself constitute entomophagy. Two varieties of phoresy occur among entomophagous insects. In one, exemplified by the scelionid, *Rielia manticida* Kieff., the adult female rides largely the female, more infrequently the male, of certain mantids. When the mantid deposits her egg mass, covering it with a frothy matrix as she proceeds, the *Rielia* females descend to the host eggs and insert their own into them. It appears to be essential for success that parasitization be accomplished while the host matrix is yet soft and the host embryo exists in an early phase of development.

In the other variety of phoresy, the active first instar larva of several parasitic groups ride the adults of their hosts, which are ants, bees and wasps. These larvae hunt or wait for the Hymenoptera on the nest site or in flowers in order to ascend upon them and to be carried to the host nests. The larvae of some blister beetles are carried by bees and wasps,—largely solitary, and eat the egg and the store of pollen-nectar mixture. Several rhipiphorid beetles gain entrance thus into the nests of wasps and bees, but parasitize the larvae. Four families of Strepsiptera possibly are carried by adult bees and wasps, and also utilize the carrier or other adults of the species as hosts. And the eucharid Hymenoptera affix themselves to worker ants whose advanced larvae and pupae they subsequently parasitize.

BIONOMIC TYPES OF ENTOMOPHAGY

The following classification of predator-prey relations is based on the kind of metamorphosis, the structural or foreign preying devices and the degree of predatism exhibited by entomophagous predators. On the other hand, the parasite-host relations are divided according to the stage or succession of stages the parasite employs as host.

PREDATOR—PREY RELATIONS

I. Hyphenic Relations. There exists a considerable number of entomophags which live as predators for only a part of the entomophagous stage, or which may exhibit predatism only occasionally, and meet the rest of their food requirements as phytophags, scavengers or even as temporary parasites. These combination food practices are here designated hyphenic relations. A few examples will make the meaning clear.

The maggots of the anthomyid fly, *Hylemya cilicrura* Rond, sometimes feed upon planted seed corn and again prey gregariously on the egg masses of grasshoppers. This case illustrates phyto-predatism. A variety of this occurs in the gland-bearing caterpillar of *Lycaena* which eats foliage in its first instars and devours the subterranean brood of ants in the last phase of its development. This abrupt change in diet is compelled by the ants that feed on the glandular secretion of the caterpillar. Predato-parasitism is exhibited by the sarcophagid fly *Wohlfartia euvittata.* Its larvae are capable of opportunistic interchange between predatism on the subterranean egg masses of locusts and parasitism in the nymphs and adults of the same locust species.

II. Absolute Predatism. This category embraces the large majority of predatory

entomophagous insects, and is characterized by the fact that the food taken by one or both feeding stages consists exclusively of insect prey.

A. *Hetermetabolous Predators.* It may be taken for granted that both nymph and adult are predators if either proves to be so, and that both possess some similar adaptations for pursuit, seizure, retention and ingestion of the prey. Several noteworthy but not fundamental differences in fitness for predation occur here.

The numerically dominant type displays front legs fitted with enlarged or spiniferous femora and tibiae, and, in the mantids, with greatly elongated coxae. Beside the Mantidae, many families of Hemiptera are thus equipped—including the well known giant water bugs, backswimmers, assassin bugs and ambush bugs. Yet the mechanical features of the front legs vary greatly in their efficiency. For example, the damselbugs use small non-resistant prey forms, whereas the ambush bugs capture insects having up to several times their own bulk. The latter make use of most flower-visiting insects ranging in size from gnats to bumblebees. In three years of collecting near Urbana, I have found *Phymata* feeding on representatives of 7 orders, 54 families, 131 genera and 195 species of insects. Its efficiency is due also to the deadly substance it injects into its victims, killing them in a few minutes and liquefying the body contents as it feeds.

Another method of attack is employed by the asopine Pentatomidae. Thrusting the forward-extended proboscis against the caterpillar, beetle larva or other prey, the stylets are simultaneously jabbed into the body. The needle-like mandibles then recurve laterally, holding the captive until inactivated, presumably by a lethal injection, whereupon the contents are drained out.

In the Odonata the metamorphosis is hemimetabolous, hence, the dragon and damselflies secure their prey on wing, while the aquatic naiads employ their extensible mask-like lower lip and its pair of apical hooks for securing prey and bringing it to the jaws.

B. *Holometabolous Predators.* Several variations of predatism are represented among insects characterized by a complete metamorphosis. In the carabid and coccinellid beetles and in the chrysopid, hemerobiid and sympherobiid Neuroptera both larva and adult have thysanuriform bodies, hunt aggressively in like habits, and seize their similar prey with their jaws. True these neuropterous larvae possess grasping-sucking jaws, whereas the adults have the simple chewing kind. But the adults and larvae of many other Holometabola live and feed in dissimilar ways. Striking cases are the Mantispidae which are presumably predacious as adults but whose larvae prey on small spiders in the egg sac, and the tiger beetles, which as adults employ their efficient running legs and sickle-shaped jaws to hunt aggressively, whereas the S-shaped body, hook-bearing dorsal abdominal bump and powerful jaws of the larvae form a remarkable machine for elevating soil, clambering up and down a vertical shaft in the ground and lying at the burrow mouth in wait for prey running across. Many solitary wasps not only paralyze prey by stinging before storing it in a nest for the future legless larva, but themselves malaxate the prey to obtain the body fluids as food. Such treatment may be accorded to prey to be stored subsequently or to a victim that serves solely to satisfy the adult wasp.

In another form of relation, only the adult uses prey as food. The calliphorid genus *Bengalia* feeds on winged termites or robs ants carrying their brood; several genera of sawflies prey on the larvae and pupae of beetles, and other insects; mecopterous hanging flies suspend themselves by the front legs to capture Diptera with the dangling hind legs, and numerous ichneumonoids, parasitic as larvae, jab their ovipositors into host insects and imbibe fluids thus liberated, not a few constructing feeding tubes to facilitate the process where the host lives under cover. The larvae in these instances are largely or wholly non-predatory.

Again many species prey only as larvae. I do not include the solitary wasps here; presumably the adults, like the larvae, will be found to feed largely if not entirely on insects or other small arthropods. Among the ichneumonoids and chalcidoids, which are predominantly parasitic, occur a few species predatory as larvae. A *Habrocryptus* consumes successively the eggs and larvae from several adjacent cells of an andrenid bee; certain *Spilocryptus* destroy the numerous larvae of *Pteromalus* parasitic in the

chrysalis of the cabbage butterfly, etc. Also nonhymenopterous instances are known. The larvae of some mosquitoes eat aquatic insect larvae; the remarkable worm lion, *Vermilio vermilio* L., a rhagionid fly, imitates the pit-making ant lions in its mode of preying; most syrphid larvae feed on aphids, whereas the adults utilize plant fluids, honeydew and the like, and not a few minute caterpillars regularly prey on various Coccidae as contrasted with the nectar-siphoning practice of the adult moths. And while many blister beetles are hyphenic in that the larvae first prey on the egg or larva, then on the stored pollen-nectar mixture of bees, the larvae of *Epicauta* and some species of *Mylabris* and other genera, destroy masses of grasshopper eggs, as do also the maggots of several bee flies.

III. *Opportunistic Feeders.* Studies of stomach contents indicate that caddis worms, an entirely aquatic order, use almost any manageable organic matter either in a state of life or decay. This seems to be true of both those fashioning portable cases and the trapnet builders, although the more primitive families of the latter group display a feeble preference for prey. In any case, however, prey forms only a variable part of the total diet.

TYPES OF PARASITE—HOST RELATIONS

The larvae of Holometabola constitute all the true parasitic entomophagous insects. The adults that practice phoresy seem not to feed on the parent host which they ride, and the behavior of the flies and Hymenoptera that feed on fluids released by thrusts of the ovipositor comes closer to predatism than parasitism.

Parasitic entomophags form a sizeable minority of the order Diptera, at least half of the order Hymenoptera and all the small tiny order Strepsiptera. Also a few beetles and Lepidoptera are entomophagous parasites. Most of the Diptera seem not to possess a piercing ovipositor, hence place their eggs or young larvae directly upon the host or at the entrance to the shaft or burrow occupied by the prospective victim. However, the female hymenopterous parasite is invariably equipped with a boring ovipositor which is employed to penetrate either the body wall of free-living hosts, or the protecting cover and, in some cases, the host as well, that lives in some sort of shelter such as a cocoon or plant cavity. Accordingly, the legless majority of the larvae find themselves on or in the host when they begin their active life. However, both the Diptera and Hymenoptera include a considerable number that are of unusual interest for their practice of depositing numerous eggs remote from the host. Parasitization then depends on (1) ingestion of the egg by the caterpillar host as it eats foliage or (2) the locomotor or waiting activity of the young larvae, that attach to and bore into the host when it is reached. The primary larvae of the Strepsiptera seem to rely on their fleet-footedness or a carrier to bring them to the new hosts. In the former instance, the hosts are saltatorial Homoptera, in the latter aculeate Hymenoptera.

The classification of parasite-host relations presented below is based on the host stage or succession of such stages the parasitic larva requires for its development. Usually also the egg, and in many cases the pupa, are found on or in the host, whereas the adult lives free.

I. Parasites of Hetermetabolous Nymphs and Adults. Many Hymenoptera and Diptera and some Strepsiptera use this subclass of insects as hosts. Ichneumons and chalcids commonly parasitize the nymphs and adults of both Hemiptera and Homoptera, and the dryinid wasps mostly initiate their attack within jumping Homoptera and complete it externally in a sac formed of the larval exuviae. Some sphecoid wasps, typified by the cicada killer, *Sphecius speciosus* store but one paralyzed insect, hence fall within the realm of parasitism, whereas most species store two or more prey insects, hence must be rated as predators.

The chironomid fly, *Trissocladius equitans* Claas. is ectoparasitic on a may fly nymph, an aquatic host; the planidial larvae of cyrtid flies stand up by aid of a caudal disc in order to attach to spiders; certain sarcophagid flies larviposit on grasshopper nymphs or even the flying adult, and the tachinid *Trichopoda* and others inject eggs or larvae into various terrestrial bugs.

Members of several strepsipterous families endoparasitize jumping Homoptera. The active primary larva issues from a puparium-like case occupied by the grub-like female on the old host and mounts new nymphs of the host species, boring

into it at the intersegmental membranes and absorbing nutriment from its blood. In the final or seventh instar, the larva pushes the cephalothorax out between the abdominal segments of nymph or adult. The apodous female undergoes no recognizable pupal stage, whereas the male does so and bears legs and a pair of functional wings.

The minute caterpillars of several moths parasitize various coccid Homoptera internally. The Epipyropidae, however, should probably be regarded as scavengers, not as entomophags, because their food, in observed cases, consists of wax or excretions derived from their homopterous hosts.

II. Parasites of Insect Eggs. Most of the numerous Mrymaridae and Scelionidae, and some other miscroscopic Hymenoptera, pass their entire egg, larval and pupal stages exclusively as solitary endoparasites of the eggs of other insects. However, a few species of this order that attack eggs laid in masses, e.g. Mantidae, do so externally. Again, *Trichogramma* species are gregarious, the number of individuals developing in one egg being correlated with the size of the host. More than 150 host species of six orders are known to be used by *T. evanescens* Westw.

III. Parasites of Insect Larvae. Insect larvae doubtlessly are utilized to a much larger extent as hosts than any other metamorphic insect stage. Numerous examples are known to occur among the Hymenoptera and Diptera and a few in the order Coleoptera, and their larval hosts belong principally to the Lepidoptera, while the beetles, flies and Hymenoptera also appear on the list. Altogether they represent almost every kind of relation to the host, living outside or inside singly or in numbers, and as primary or secondary parasites. In addition, the female ichneumonoids, chalcidoids, parasitic vespoids and others may puncture or malaxate the host and feed on it previous to oviposition, or, in some cases feed without subsequently placing an egg. The above wasps and some ichneumonoids paralyze the host, either in part and temporarily, or wholly and permanently, before depositing the egg.

A parasitizing process of unusual interest appears in the primitive Trigonalidae. The numerous microscopic eggs are placed in foliage remote from the hosts, and the larvae have been reported as secondary parasites of ichneumons in caterpillars or sawfly larvae, and as primaries in the larvae of *Vespa*. According to observations, the trigonalid eggs are ingested by the caterpillar or sawfly as they eat foliage, whereupon the small parasitic larva attacks the primary ichneumonid parasite already present in the primary host.

However, the *Vespa* grub does not eat foliage and contains no ichneumonid primaries. How, then, does the trigonalid gain entrance into the wasp host? Clausen theorizes plausibly that the parent wasp fed parts of trigonalid-parasitized caterpillars or sawfly larvae to her grubs, a mode of feeding practiced generally by social vespoids. Thus, he believes, the parasitic larva was ingested along with the prey larvae provided by the parent,—a simple mechanical, incidental transfer of the trigonalid from its original host to a second.

The Eucharidae, Perilampidae, a number of tachinid flies, and others likewise place numerous microtype eggs on leaves, buds or in soil irrespective of the host's location. The parasitic, active first instar, primitive-type larva then gains entrance in one of several ways: ingestion by the host of the egg along with its plant food (some Tachinidae); the locomotor activity of the larva itself (Perilampidae and some Tachinidae); exploratory movements of the larva while supporting itself caudally on the chorion of its egg during the wait for the caterpillar host (some Tachinidae), or by riding a worker ant whose intranidal larvae or pupae it uses as hosts (Eucharidae). The known Perilampidae are secondary parasites on ichneumons or tachinids in caterpillars. In all these cases, as also in the Trigonalidae, the larvae assume progressively reduced forms during their ontogeny, thus displaying various degrees of hypermetamorphosis.

IV. Parasites of Prepupae or Pupae. While the lines between parasitism of larvae and of pupae are naturally not sharply drawn, some Hymenoptera and a few Coleoptera develop at the expense of only the pupal stage of their hosts. For example, the chrysalids of Lepidoptera, the pupae of ladybeetles, lacewings and caddis flies, and the puparia of Diptera form the hosts of many ichneumonoids and chalcidoids, and the active running primary larvae of aleocharine Staphylin-

idae complete their parasitic life within the puparia of cyclorrhaphous flies.

V. Parasites of Adult Holometabola. A few examples are cited to elucidate this relation. First, *Elasmosoma* inserts her eggs into the abdomen of *Formica fusca* within the nest, *Syrrhizus* parasitizes *Diabrotica* beetles, and *Perilitus coccinellae* Schr. uses lady beetles exclusively. These are braconid Hymenoptera. In the order Diptera, we find certain ceratopogonid flies suck blood from the wings, or other body parts, of caterpillars, dragonflies, etc., while a conopid makes the ovipositional attack on wasps and bees in air, and the tachinid, *Chaetophleps setosa* Coq. likewise seems to attack *Diabrotica* when these are on wing exposing the vulnerable dorsum of the abdomen. The Strepsiptera concerned here are endoparasitic in wasps and bees. The procedure in parasitization and development is similar to that of those which utilize homopterous hosts, with the possible exception that the primary larvae may practice phoresy which facilitates finding new hosts, particularly such as are social.

VI. Parasites in Consecutive Host Stages. This category embraces not a few ichneumonoid, chalcidoid and even serphoid Hymenoptera which utilize either two or three successive stages of holometabolous hosts to accomplish their life cycles. Three such combinations have been shown to be employed to date, namely egg-larva, larva-pupa and egg-larva-pupa. The hosts include Lepidoptera, Diptera and Coleoptera. For example, the chalcidoid, *Tetrastichus asparagi* Cwf. inserts an egg into that laid by the common asparagus beetle on its food plant. The parasite does not interfere with the embryonic development of the host, but makes its development at the expense of the beetle larva. The latter is permitted to complete its growth and to proceed normally to the soil and form the usual pupal cell. But its life is terminated before pupation by the final feeding activity of the endoparasitic *Tetrastichus* larva.

Representatives of the chalcidoid genera *Ageniaspis*, *Encyrtus*, *Copidosoma*, *Berecyntus* and *Litomastix* similarly utilize the egg-larval stages of Lepidoptera, whereas the serphoid genus *Platygaster* may employ the egg-larval host sequence of tiny nematocerous Diptera; these genera are, in addition characterized by polyembryony that works itself out in the larval host.

Several examples are known also in the Braconidae and Ichneumonidae. Where the host relation involves the larva-pupa succession, the parasitic larva hatches in the larval host but, in some cases, larval feeding and development is delayed until the host attains the pupal period. In such instances it is believed the histolytic changes accompanying pupation constitute the stimulus necessary to initiate parasitic activity. It may therefore be surmised that this fact, plus the unfavorable size differential between parasite and host, explain at least in part the need for a succession of host stages required in the above instances for the success of the parasite.

CONCLUSION

An extensive panorama of entomophagous food relations has passed in quick review. Only a small fraction of the known cases exemplifying the several relations described are cited above. Moreover, a considerable number of confusing exceptions have been omitted in the interest of simplicity. Readers interested beyond this brief attempt to portray the diversity and fascination inherent in the bionomic relations of entomophags and their prey and hosts are invited to consult the several more comprehensive treatises cited below.

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INSECT RELATIONS WITH PLANTS*

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The insects comprise by far the great majority of animals on the face of the globe. In the evolution of life, they originated about the same time as the seed- and flower bearing plants, and since that time, the relations between the two have been of the utmost intimacy. Both insects and plants have been modified in numerous ways to sustain this relationship or to protect one or the other from the deleterious effects of such close and greedy company.

It is immediately apparent that, with the possible exception of the plant enemies of insects, either the aggressiveness of insects in their quest for food or their desire for shelter or refuge, or a combination of both, almost always is the underlying reason for relations between insects and plants.

Probably the desire for food is the most important of these two reasons since more complex and far-reaching results come from it.

No terrestrial plant, not even the dreaded poison ivy, is free from insect feeders, and some, such as our larger trees, are hosts to a thousand or more species. No part of the plant, from the deep roots to the high branches, from the tough outermost bark to the woody innermost pith, from the hardest seed, the waxiest leaf, or the spiniest branch to the daintiest flower, the softest fruit, or the most succulent shoot is free from insect attack.

Only plants in salt water are out of reach of insect depredations, for most, if not all, of the extremely few insects which venture a greater or lesser distance into salt water, are of predacious rather than phytophagous habits. Fresh water plants are often eaten or tunneled into by insects, punctured for the deposition of eggs, or otherwise utilized for protection, by a number of families of several orders of insects.

Of the terrestrial plants, those higher in the evolutionary scale probably harbor the greatest number of insects, but even the lowest forms have their characteristic species. Great numbers of insects are known to exist on the microscopic organisms which cause decay. Even the hard fungi are often riddled by small borers, usually beetles, which are limited to them as a habitat. While making botanical collections on tropical mountains I have split open fleshy mushrooms only to find more fly maggots there than plant meat. The ferns seem to be unusually free from insect attack, though by no means completely so.

Now that we have briefly indicated the extent to which insects will feed on plants, one of the next most important questions concerning this relationship, that of the specificity of relationship between the feeder and host, presents itself. This question is of interest both to the biologist who studies the evolution or bionomics of these forms and to the applied scientist who must fight the insects attacking crops.

Certain insects are known to feed on as many as 200 kinds of plants. When such an omnivorous phytophagous, or polyphagous, feeder is of importance in planted fields, as it might easily be, it may be very difficult to control because of the almost unlimited opportunities for sustinence. The corn earworm is one of the best examples, the tarnished plant bug is another.

However, it is probably more common to find that plant eating insects are more or less restricted to a certain group of plants, whether it be a single order, a single family, or a single genus, or any closely related group of any of these catagories. Insects which feed within such a restricted group are termed oligophagous feeders.

The monophagous feeders, the ones restricted to one kind of host, are frequently encountered among insects. Every school boy who tries to rear larvae knows how careful he has to be to provide just

* Exclusive of Pathogenic.

the right kind of leaves for certain of them.

Certain insects, such as the aphids and the potato leafhopper, alternate their specific hosts from season to season. The possibilities of different hosts for a single species are further increased and complicated by the different stages in the metamorphosis of insects. As a general rule, I believe, nymphs feed on the same host or hosts as the adults, but larvae may or may not feed on the same host as the adults. Larvae in most cases feed on at least a different part of the plant from the adults. For instance, the larvae of the famous Japanese beetle feeds on the roots of grass, vegetables, and nursery stock, while the adults feed on the foliage and fruits of about 250 different kinds of plants of a great taxonomic variety.

As generalized insect groups evolve into more specialized forms it is generally conceded that they also acquire more specialized feeding habits. Under pressure, a specialized feeder can adapt itself to new varieties of the preferred plant. Once an insect has been able to survive on a certain kind of plant over a period of several generations it may more or less completely refuse to consume its original food plant. Biological races of the same species, one of which will not feed on the host of the other, are known for a number of insects. These races can sometimes be distinguished by slight morphological modifications or by changes in habits or in the life cycle.

While it is true that insects can and do change their feeding habits, especially in times of stress, it appears to be the general rule in Nature that many prefer the food plant upon which they hatched. According to Hopkins Host Selection Principle, the female of a species which can breed in two or more hosts will prefer to lay her eggs on the same host on which she fed, and that this physiological attraction will tend, in the course of many generations, to develop a physiological race of insects more or less restricted to the preferred host.

Plants in Nature have evolved numerous ways of protecting themselves from insect attack, but during the selection and breeding of plants for cultivation, many of the resistant properties have been lost. Cultivated plants are not only grown in large stands favorable for the concentrated attack of insects, but they also are most attractive to insects and themselves suffer more severely from insect feeding. The plant breeder is often faced with the process of rebreeding, if such a word might be used, these resistant qualities into his crop. Imms[1] lists the factors which contribute to the resistance of a plant or lack of resistance of a plant as the thickness of the cuticle, the development of the sclerenchyma or other mechanical tissue, general hairiness or its absence, acidity or alkalinity of the cell-sap, silica content, presence or absence of certain glucosides, date of maturity, and power of recuperation. It has also been observed that the cell-sap of certain varieties or species of plants directly effects the fecundity of sap-sucking insects which feed on them.

By their feeding habits, insects sometimes perform great service to the plant and to the agriculturist. One of the most publicized of the direct benefits to the agriculturist is that of the many kinds of cactus feeding insects which have been sent from North America to Australia to combat the extensive growth of the prickly pear, itself imported from North America, which has inadvertently established itself and covered enormous areas of grazing land.

By their intimate association with certain plants a number of insects, especially bees, perform a value of incalculable immensity in the cross-pollination of flowers. Most flowering plants are strongly modified to utilize this insect service and so to produce seed which will result in vigorous and fertile offspring. The colors of the plants attract the insects to the nectar cups deep within them. As the insects press into the flower to obtain nectar or pollen, they pass by structures marvelously designed in one manner or another to leave pollen on the hungry visitor or to retain the pollen brought by him from a previous flower. By their habit of feeding mainly on plants of one species, the probability of cross-pollination by insects is greatly increased.

The modifications of flowers, besides those of color and odor, are indeed remarkable. In the flower of the common Japanese barberry the stamens are adapted so that there is a turgor move-

[1] Imms, Recent Advances in Entomology.

ment in response to the stimulus given by the touch of a visiting insect's foot. This movement appresses the anthers to the leg of the insect, so effecting pollinization. The common iris has a platform for visiting bees formed by three sepals. The anthers are just above the platform on which the bee rests to obtain nectar and are just at the proper height to leave some of their pollen on the branched hairs of the back of the insect. Then as the bee enters the next flower, some of the pollen is scraped off the back on the stigmatic surface of a flap under which it must pass to reach the platform. Pollination of the same flower from which the pollen is received is prevented because the surface of only the flap that is met while entering is receptive to pollen; that met while leaving is non-receptive.

Our common milkweeds are so designed that little pollen bearing structures are attached to the legs of visiting insects when they slip into beautifully designed grooves of the flower in their attempt to obtain nectar. These structures, called pollinia, twist on their stalks after being removed from their flower and are then in a position to remain in the stigmatic chamber of the next milkweed visited. One often finds insects which are not powerful enough to extricate their legs from these grooves hanging dead or dying from milkweed flowers. The yucca moth has specially adapted mouth parts and a strong ovipositor, such as is possessed by no other moth, with which it carries on activities upon which the yucca is entirely dependent for pollination. With these mouth parts, the female scrapes pollen from several yucca flowers and then by means of her ovipositor inserts her several eggs into the ovary of another flower after which she pushes the pollen into the stigmatic tube and departs. There is, at present, no conclusive explanation for these strange actions, for the female does not feed and the larvae which develop from the eggs eat only a few of the several seeds among which they are laid.

The shapes of the Orchidaceae, which are entirely dependent upon insect pollination, are the most fantastic of all floral developments. In some species special adaptations are formed for depositing pollen on the eyes of a visiting sphinx moth and for reclaiming this pollen when the moth visits the next individual. Some of our most valuable crops, as for instance, many of our fruits and clover, are entirely dependent upon insect visits and pollination for their continuation from season to season.

Flowers are more noticeably modified than insects for pollination because of their utter dependence upon them, while the insect's purpose is usually accomplished when it obtains the nectar or pollen that the plant has to offer. However, there are a number of structural modifications present on insects which visit flowers that are not found on other insects and which make the service of cross pollination more effective. Some flies and many bees have hairy bodies and legs which gather and hold pollen until scraped off on the next flower. The hairs of pollen-gathering bees and of some flies are branched or feathery so as to insure the adherence of pollen. For the mere gathering of pollen or nectar, honey bees and sphinx moths have extremely long tongues to reach the nectaries.

Sometimes after we have pitched our tents under trees in the semi-desert scrub of Mexico we have awakened the next morning to find the trees entirely stripped of their leaves and the ground below them littered with the cut edges of the leaves. The leaf-cutting ants of warm climates go to such great effort in order to bring these cut leaves to their nests to use them as a culture media for the propagation of fungus upon which they subsist.

Plant galls caused by insects are so common that one cannot walk into the field without seeing numerous examples of infinite variety. There is little explanation for these curious and varied shapes that the plant tissues assume when certain insects lay their eggs or feed in or on the plant. It is even more amazing to find that in many cases the insect apparently determines the shape of the gall, although the gall is entirely a plant growth. One species of insect may cause similar galls on different species of plants but the galls of different species of insects on one and the same plant may be entirely different. It is usually supposed that the gall does not develop until the larva hatches. However, some galls are completely formed between the time the egg is laid and the larva hatches. Others seem to need a continuation of stimulation from the larvae that live within them. Often galls containing healthy

larvae can be distinguished from those containing sickly larvae. Galls are found on almost every part of the plant, the roots, leaves, flowers, stem, and seeds. They are caused by a great many kinds of insects and are found on many kinds of plants. The simple nodular galls of the Hessian fly and the wheat joint worm are of extreme economic importance because of the debilitation of the plant while certain foreign galls are used for fuel, food or dyes.

Seed dispersal by insects is restricted almost entirely to the ants. In the western grasslands we often see the rings of grasses that surround the subterranian nests of the agricultural ants that have brought their seeds there for storage. It is said that the seeds of a certain species of bloodroot have fleshy handles by which ants carry them. According to some authors, the seeds of another plant so closely resemble the pupae of certain ants in size, form, and odor that these ants carry them from place to place although they do not use them for food.

Of importance secondary only to feeding is the protection offered by plants to insects. The innumerable possibilities of concealment offered by plants are easy to imagine. The plant may simply offer refuge from enemies or weather. For instance, while collecting in the rain on one of the deserts of southern Mexico, we once encountered within three or four minutes almost fifty specimens of a rare family of Neuroptera huddled in the crevices of the bark of a poisonous tree, but when the rain subsided none were to be found, and indeed, we collected only one other specimen in the general vicinity during the whole month. Often feeding and protection go hand in hand. Scores of our most common insects feed on the underside of leaves where they are hidden from many of their natural enemies. Root eaters usually have little to fear from predators or parasites. It is obvious that borers into stems or wood have almost no enemies to fear, especially if they bore beyond the reach of woodpeckers and other strong beaked, hard working birds. Leaf miners, of which there are many more than the average person realizes, go about their business of eating inside of the leaf in which they are living entirely or relatively unharmed. The bagworm utilizes twigs and leaves from the plant on which it feeds to spin into its silken web, and so makes a cozy little house which it carries on its back to shield itself from at least some of its many potential enemies, although many tiny parasites may still attack it. Even the aquatic Trichopterous larvae make cases of plant material for protection, but often the larvae do not feed on the plant which protects them.

Many insects utilize the interior of plants for egg laying, thus protecting the eggs from many dangers. Sometimes the young which hatch from these eggs stay within the plant, as is the case of the larvae of the engraver beetle, but many others, such as the nymphs of cicadas, fall to the ground upon hatching, or others, such as the nymphs of treehoppers, emerge and live on the outer surface of the plant.

Leaf cutting bees cut leaves with which to line the nests in which they place honey and pollen for their larvae, and then plug these nests with more cut leaves. The solicitude with which some ants place aphids on plants so as to secure their sweet offal is well known. On the desert, we have seen neat little round "stables" for these aphids, made in the crotches of branches from pieces of gravel cemented together.

We have already noted that many plants have evolved structures or other modifications to protect themselves from insect attack. Numerous insects have been so modified as to obtain protection from their enemies because of their similarity in color or structure to the plants among which they live. The common katydid is often overlooked because its green color blends so well with the bark or leaves among which it rests. *Catocala* moths, though brilliantly colored on the under wings and under surfaces, blend perfectly with the bark as they rest there with only their upper surface visible. The undersurface of the remarkable *Kallima* butterfly of India, exposed as it rests among dead leaves, exactly resembles these leaves so that it is remarkably difficult to distinguish.

Insectivourous plants, while rare and of little importance in the economy of Nature, nevertheless are of great interest biologically. In the well-known pitcher-plants of our marshes, the leaves and petioles are modified into brilliantly colored, sweet-scented pitchers provided with nectar glands which lure sweets-

loving insects into their sticky depths. Then, when the victim dies from exhaustion after its unsuccessful attempt to extricate itself, this marvelously developed plant slowly digests its unchitinized tissues. Strangely enough, the pitcher-plant is the home of a genus of Noctuid moths which oviposit in the pitcher and whose larvae feed on its tissues and even spin a web across the opening, thereby protecting themselves from spiders and other enemies.

The leaves of the sundew are provided with hairs, each with a fluid secreting gland. An insect that flies to one of these leaves is trapped when the hairs enclose over it and is digested by the secretions from the glands. When the digestion has been completed the leaves open in anticipation of the next victim. Each of the leaves of the Venus fly-trap of the coastal regions of North and South Carolina slant upward from the middle and clamp over an insect which alights on it. Sharp bristles along each margin prevent escape of the larger victims, but small insects, which contain little nourishment anyway, can escape between the spines. The trapped insect is digested by fluids on the glands on the leaf's surface.

Of great interest, especially to medical entomologists dealing with the problem of mosquito abatement for the control of malaria or yellow fever, are such aquatic plants as the common *Lemma* which often covers the surface of water so closely that mosquito larvae cannot find place to extend their breathing apparatus through the surface film to obtain air.

Some insects actually guard plants. I was made painfully aware of this relation a few years ago while walking through the tropical scrub country of southeastern Mexico. While in quest of a particularly fancy flying beetle, I brushed against the sharp spines of the bull-horn acacia, one of the most common leguminous plants of the area. I was immediately sharply bitten by a number of large ants which rushed out from holes at the ends of the spikes shaped like the horns of bulls, for which the plant is named. These hollow horns shelter the ants, which, in turn, supposedly drive off the leaf-cutting ants which are so common in the region. They also drive off innocent entomologists, which are much rarer. In addition to the shelter which the acacia offers the ants, it also offers two kinds of food which are the ants' chief subsistence, a sweet fluid which they obtain from the bases of the petioles, and also little round knobs rich in albumin which they pick from the ends of the leaflets. In the tropics there are several other such plant houses with insect guards.

INSECTS AS VECTORS OF PLANT PATHOGENS

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It is appropriate in particular degree that the rôle of insects as vectors of plant pathogens should have a prominent place in this Symposium. In 1881 Thomas J. Burrill, Professor of Botany at the University of Illinois, demonstrated for the first time that bacteria could cause disease in plants and were the cause of fireblight of pears and apples. In 1884 Stephen A. Forbes, then State Entomologist, expressed the opinion that fireblight was spread by the tarnished plantbug. And in 1891 M. B. Waite, until 1887 a student under Burrill, reported experiments proving that bees and wasps commonly spread fireblight from blossom to blossom. Thus, at the University of Illinois, was born the conception of an active and intimate association between insects and plant diseases.

The development of this conception by plant pathologists and entomologists is well exemplified by the time of publication of 655 research reports making notable contributions to the problem. Only seven of these reports appeared prior to 1900, but in succeeding years the number increased rapidly. From 1901 to 1905, ten reports appeared; from 1906 to 1910, twenty-one appeared; from 1911 to 1915, thirty appeared; from 1916 to 1920, forty-one appeared; from 1921 to 1925, seventy-one appeared; from 1926 to 1930, one hundred forty-six appeared; from 1931 to 1935, two hundred and two appeared; and from 1936 to 1940, one hundred twenty-seven appeared.

With so large a number of researches completed, it must be apparent that a large body of information has been developed and that within the time permitted today little more can be presented than a bold outline of what it contains, as illustrated by a number of selected examples of diseases and vectors.

HISTORICAL

The first suggestion that an insect was associated as vector with a plant disease was made by Forbes in 1884. The first proof that insects function as vectors was published by Waite in 1891. Milestones in the elaboration of knowledge of the vector rôle of insects may be listed as follows:

1901.—Takami, a Japanese, showed that the dwarf disease of rice, not then known to be a virus disease, resulted from the feeding of the leafhopper *Nephotettix apicalis*.

1906.—Ball, in America, showed that curlytop of sugar beet was associated with the leafhopper *Eutettix tenellus*.

1909-1910.—Petri, in Italy, showed that olive knot was transmitted by the olive fly *(Dacus oleae)* and that an intricate symbiotic association obtained between the pathogen, another bacterial organism, and the insect.

1911.—E. F. Smith, in America, showed that bacterial wilt of cucurbits was transmitted by the striped cucumber beetle *(Diabrotica vittata)*.

1911.—Norton, in America, published a classification of insect injuries to plants, in which insect dissemination of pathogens was recognized.

1912.—Allard, in America, showed that tobacco mosaic was transmitted by aphids.

1913.—Heald, in America, summarizing the dissemination of plant pathogenic fungi, recognized the importance of insects as vectors.

1918.—Ball, in America, demonstrated that potato hopper burn resulted, as a toxic effect, from the feeding of the leafhopper *Empoascus fabae*. He thus established a new concept, that of disease being induced by toxicogenic insects.

1921.—Buchner, in Germany, published elaborate studies of the symbiotic phenomena occurring between microorganisms and insects.

1926.—Kunkel, in America, showed that an incubation period in the body of the insect is required for transmission of aster yellows.

1929.—Böning, in Germany, published an extensive critical review of the literature on insects as carriers of plant diseases.

1937.—Kunkel, in America, showed that the virus of aster yellows in the body of the leafhopper can be inactivated by exposure of the insect to a temperature of 31° to 32° C.

1937.—Hartzell, in America, reported the finding of intracellular inclusions in the intestinal walls and salivary glands of viruliferous *Macropsis trimaclata*, the leafhopper vector of peach yellows.

1937.—The American Phytopathological Society, the Entomological Society of America, and the American Association of Economic Entomologists staged an elaborate symposium on insects in relation to plant diseases.

1940.—Leach, in America, published the first book dealing with insects as vectors of plant pathogens.

EXAMPLES OF INSECT TRANSMISSION

Diseases due to phytotoxic insect secretions.—The outstanding example is the mealy bug wilt of pineapple, a disease known in Hawaii since 1910 as the most important cause of pineapple failure. Leaves of affected plants become flaccid, droop, turn pale or become pink or red. On young plants progress of the disease is rapid, but recovery occurs commonly. On old plants progress of the disease is slow and affected plants never recover. On young plants an initial population of fifty mealy bugs *(Pseudococcus brevipes)* is sufficient to induce the disease. On older plants the disease develops slowly, as a large population of mealy bugs develops from an initial small number, and is accompanied by collapse of the roots and final destruction of the plants.

The disease is not caused directly by the feeding of mealy bugs but by a phytotoxic substance injected into the plants by the bugs as they feed. The phytotoxic substance is apparently diffusible in the plant but is not capable of reproduction there. The failure of plants to wilt quickly when colonies of mealy bugs are built up slowly from small intial populations has been interpreted as the result of an anti-toxic reaction on the part of the plant. In general, the wilting of plants increases with the number of mealy bugs, but the increase is not directly proportional; and there appears to be a point on the bug dosage scale beyond which there is only a small increase in the number of wilting plants.

Another disease of the same kind, one familiar in America, is hopper burn of potato. This disease follows the feeding of *Empoascus fabae*. It differs from the mealy bug wilt of pineapple in that it is not limited to just one of the hosts used by the causal insect. It affects alfalfa, clover, apple and other plants also, and may severely damage them.

Explanations other than that of a diffusible toxic substance have been offered for the injury done by toxicogenic insects. It has been suggested that accumulation in excess of carbohydrates above the point injured by the insect is sufficient cause for the injury. However, *Empoascus fabae* feeds almost exclusively in the phloem elements of the vascular bundle, and the line of penetration is surrounded by a region of disorganized cells not producible mechanically, as for example by probing with a fine glass needle. Presumably, then, pathological disorganization of plant cells must follow the injection of at least some toxic material. Since other leafhoppers that feed in the vascular elements of the plants cause less injury, or none at all, differences in amount of injury can most logically be attributed to differences in toxicity of the salivas of the different leafhopper species. The concept of toxicity is, nevertheless, poorly defined, and it is well, therefore, to consider that injury displayed by plants could result from excessive abnormal physiological reactions induced by toxic materials, as well as from the direct action of toxic substances.

Fungus diseases transmitted by insects.—A great variety of associations between fungi and insects is exhibited by the known cases in which insects serve as vectors of fungous pathogens. Commonly, these associations appear based on the search for food by insects. The ergot diseases of rye and other grasses furnish fine examples.

In the spring, ergot kernels that have lain dormant on the ground over winter send up globe-capped stalks. Beetles, and also other insects that visit the blossoms of grasses, are attracted to these globular caps and become contaminated with ascospores of the ergot fungus. Crawling or flying then to rye and grass heads, these insects deposit spores in the blossoms and infection is accomplished. As the new ergot develops, a conidial type of spore is borne in droplets of honeydew. More than forty kinds of insects, includ-

ing especially flies and a fungus gnat *(Sciara thomae)* have been observed feeding on this spore-bearing honeydew. Insects that habitually visit both healthy and diseased grass heads in their search for pollen and nectar are obviously effective agents in spreading ergot infection from blossom head to blossom head. The relationship between fungus and insect is, however, purely casual and accidental. The fungus evidently is not the food sought by the insect, since it has been demonstrated that its spores pass through the alimentary canal of the insect without losing their viability. The only obvious adaptation apparent in the relationship is that the fungus, as it develops in the grass head, produces a carrion-like odor that seems especially attractive to flies.

A more restricted relationship exists between a number of wood staining fungi and certain bark beetles. Fungi, chiefly of the genus Ceratostomella, attack the sapwood of certain coniferous and deciduous trees important in industry, not rotting but killing and staining in shades of blue and brown the wood they invade, and thus decrease the commercial value of lumber obtained from the trees. Affected trees usually have been weakened by fire or drought previous to infection. Inoculation with these fungi is accomplished chiefly, if not exclusively, by bark beetles as they bore into the trees and construct their galleries. The fungi, after penetrating the wood of the tree, fruit in the brood galleries of the insects and thus contaminate the young beetles. Invariably, spores of these fungi are borne in a sticky matrix, an adaptation assuring that new broods of beetles will be well contaminated externally as well as internally when they emerge from the trees.

In some instances, the association of stain-producing fungi, insect species and tree hosts is not closely restricted. For example, the blue stain fungus *Ceratostomella ips* is carried to Norway pine logs by two species of bark beetle, *Ips pini* and *I. grandicollis*. It can also be carried to other coniferous species by at least three other species of the same bark beetle genus. On the other hand, the association may be rather strict, as in the case of two brown stain fungi affecting white fir. One of these fungi, *Spicaria anomala*, is found only in the top and branches of the tree, where it is introduced by *Scolytus praeceps* and *S. subscaber*. The second fungus, *Trichosporium symbioticum*, is found only in the base of the tree, where it is introduced by *Scolytus ventrales*. Although it has been shown experimentally that either of these fungi will grow in any part of the tree artificially inoculated with them, their occurrence in nature only in definite portions of the tree is clearly associated with their dependence on specific insect vectors.

The relationship existing between blue stain fungi and bark beetles may be regarded as an instance of mutualistic symbiosis. The fungi apparently are of no significance as food for the insects. Their rôle is apparently that of making the wood which they parasitize a more suitable habitat for the beetles, and this they accomplish by killing the cambium of the tree and reducing the moisture content of the sapwood. The service rendered by bark beetles to wood-staining fungi is apparently limited to that of transport and insertion into the tree.

The well known dependence of plants on insects for pollination is also a means for the spread of disease. In Russia and in Wales, red clover is affected systemically by a fungus known as *Botrytis anthophila*. This fungus fruits on the anthers of affected plants, destroying the pollen grains and replacing them with masses of spores. The vigor of the plant is not impaired, and blighted anthers constitute the only symptom of disease. Because of the destruction of pollen there is, however, a decrease in seed yield. Bees, upon which red clover is largely dependent for pollination, visit the flowers for nectar, become contaminated with the Botrytis spores, and carry them to the stigmas of flowers on healthy plants. Here the spores germinate. The mycelium penetrates the ovary, remains within the seed until it germinates, and then grows systemically within the young plants. It again appears in fruiting condition when the flowers mature.

Insects can be extremely important as vectors in indirect ways, as for example in the diploidization of fungi. One of the most recently discovered rôles is that of flies and perhaps other insects in the fertilization of heterothallic rust fungi. With these fungi, reduction division occurs in the germinating teliospore. Sporidia produced after this germination give rise to haploid mycelia. Infection

by these sporidia results in the formation of the structure known as a pycnium, in which are produced numerous minute pycniospores and certain elongated hyphae regarded as trichogynes. Pycniospores exude from pycnia in drops of a fragrantly scented, sugary solution eagerly sought by over 135 observed species of insects. As insects feed on the sugary solution, they become contaminated externally and internally with pycniospores, which they deposit in other areas of infection. Flies, perhaps because of their tendency to regurgitate, appear to be the most important carriers of these spores.

When pycniospores are deposited on infected areas other than the one from which they came, they adhere to trichogyne filaments, unite with them, and accomplish diploidization. This immediately results in production of the cluster cup stage of the rust fungus.

Constant cross-fertilization of rust races by insects increases opportunities for hybridization and variation. It not only accounts for the large number of physiologic forms occurring in such important rust species as the stem rust fungus, *Puccinia graminis*, but also makes it very probable that success in breeding economic plants for resistance to heterothalic rust fungi will always be only temporarily successful.

Bacterial diseases transmitted by insects.—The bacteria known to be pathogenic in plants exceed 200 species. With few exceptions they are unicellular, rod-shaped organisms of such simple structure that they are able to penetrate plants only through natural openings or injuries. Insects that penetrate the epidermis of plants are therefore especially useful as vectors; but in many instances insects also serve as chance or accidental carriers, depositing bacteria on or near natural openings in the plant—stomata, hydathodes, and nectaries.

A great many instances of insects serving as vectors for bacterial plant diseases are recorded in the literature of plant pathology and entomology. Many of these instances never have been substantiated experimentally but are based on observation, or especially when the method of dissemination of a bacterial pathogen is not understood, on assumption. The relationship between insects and bacteria has, however, been investigated carefully in a number of instances, and it has been definitely shown that this relationship may vary from the purely casual or accidental to an extremely complicated symbiosis.

The earliest of the bacterial diseases of plants to be recognized as being spread by insects was fireblight. In 1884 Forbes, from observational evidence, associated spread of the disease with the feeding activities of the tarnished plantbug. Nearly thirty years later this association was proved experimentally. In 1891 Waite proved experimentally that fireblight is transported from blossom to blossom by bees and wasps. Since this early work, it has been proved that bees are concerned almost solely with the increase of the phase of the disease known as blossom blight, and that aphids, tarnished plantbugs, and other insects carry infection from hold-over cankers to the growth of the current year. It seems that transmission by these insects is purely mechanical and that any insect feeding on a susceptible host is a potential vector. Thus the infection of large branches and trunks may be accomplished by the fruit tree bark beetle, *Scolytus rugulosus*. The beehive has been suspected as an overwintering haven of the fireblight bacterium, and there is evidence that at least in some parts of the United States it can serve this purpose.

The rôle of insects as transporters of fireblight has perhaps been investigated more extensively and by a greater number of researchers than any other insect-carried disease, yet after nearly sixty years investigators are by no means agreed as to the rôles to be assigned to various insects. Since many means of spread other than insects are utilized by fireblight bacteria, the one point of agreement in all of the data now available probably is that insects are casual or accidental, mechanical carriers.

At the opposite extreme is the olive knot disease, which in Italy has been proved to be closely associated with the olive fly, *Dacus oleae*. The bacterium, *Phytomonas savastanoi*, causing the disease is found constantly in the intestinal tract of this insect in all its stages of development, is transmitted internally through the egg, and survives in the puparium. In the female fly, the anal tract and the vagina unite at their posterior ends to form a common opening.

Near this opening, but in the wall of the anal tract, there are a number of sac-like evaginations, which are always filled with bacteria. Immediately opposite the openings of the evaginations is a longitudinal slit in the membrane separating the anal tract and the oviduct. An egg, passing along the vagina, spreads this slit open, so that its surface presses against the openings of the bacterium-filled evaginations. In this way the egg becomes smeared with bacteria, which find their way through the micropylar opening into the interior of the egg and into the body of the developing embryo. Larvae are, consequently, always contaminated internally before they hatch. Near the forepart of the mid intestine of the larva are four spherical caeca that harbor the bacteria, and from these caeca as points of origin bacteria are continually being distributed throughout the length of the intestinal tract. In the larva, during pupation, a spherical diverticulum develops off the esophagus and just in front of the brain of the pupa, and this diverticulum becomes filled with the bacteria. Here the bacteria persist, and when the fly emerges it also is always internally contaminated. Shortly after the imago emerges, the entire intestinal tract, including the anal sacs, becomes contaminated from the diverticulum. In this way, persistence of the bacteria in the body of the insect is assured. Transmission of the bacterium to the olive tree occurs by way of the wound made during oviposition.

Another, non-pathogenic bacterium, *Ascobacterium luteum*, occurs constantly in the body of the olive fly, in the same places as the olive knot bacterium, apparently in symbiosis with the olive knot bacterium, and frequently in much greater numbers than the olive knot bacterium. What relationship exists between the olive fly and the two bacteria it harbors has not been determined; but it may be assumed to be some high type of symbiosis, since special structures have developed in the body of the insect to further the relationship.

The olive fly is not the only means by which olive knot can be spread. The disease is not uncommon in California, but the olive fly does not occur in that state. There the disease is apparently distributed by wind-blown rains.

An instance in which a bacterial pathogen is entirely dependent for spread upon a definite kind of insect is furnished by the bacterial wilt of cucurbits. As a result of the presence of *Erwinia tracheiphila* in their vascular bundles, cucumber, cantaloupe, squash and pumpkin plants wilt and die. Primary infection of these plants always originates in the spring from the feeding of overwintered striped cucumber beetles, *Diabrotica vittata*, in the bodies of which the bacterium also overwinters. After the disease is established in a plant, it can be spread to other plants by both the twelve-spotted cucumber beetle, *D. duodecempunctata*, and the striped cucumber beetle. Experimental work has established that these two insects are the only insects capable of harboring and spreading the disease and that the squash bug, the squash ladybird, the melon aphid, the honey bee and the potato flea beetle are not vectors. Although the bacterium lives over winter in the body of the striped cucumber beetle, it is not known that any symbiotic relationship exists between the bacterium and either of its vectors.

Virus diseases transmitted by insects. —Since 1912, when Allard showed that tobacco mosaic was transmitted by aphids, the number of proved instances of insect transmission of viruses has increased so greatly that now the number of insect vectors much exceeds the number of recognized plant pathogenic viruses. Here, also, the relationships between the viruses and their vector insects are variable, ranging from casual mechanical transmission to biologically obligatory associations.

An instance of a highly infectious virus being transmitted mechanically by many different insects is furnished by the spindle-tuber disease of potato. This disease, first recognized in 1922 and proved to be of a virus nature in 1923, is of considerable economic importance. Its virus is easily transmitted artificially by inoculation with infected sap, by contact between cut seed pieces, and especially by the cutting knife. Positive transmission has been proven experimentally for the following insects: the aphids *Macrosiphum gei* and *Myzus persicae*, the tarnished plantbug, larvae of the Colorado potato beetle, the flea beetles *Epitrix, cucumerus* and *Systena taeniata*, the leaf

beetle *Disonycha triangularis*, and grasshoppers of the genus *Melanoplus*. The only insect that has failed to give positive transmission in tests is the leafhopper *Euscelis exitiosus*. The fact that so many insects are able to transmit the spindle-tuber virus suggest that almost any insect feeding on potato is a potential vector of the disease. This facility for insect spread undoubtedly accounts for the very rapid increase of the disease in the field, which may reach the extent of 42 to 95 per cent of the plants in as short a time as three years.

Leafroll of potato, also an economically important virus disease, is less readily transmitted than is spindle-tuber. It cannot be transmitted by mechanical inoculation with virus-infected sap. It can, however, be transmitted by such insects as the plantbug, *Calcoris bipunctatus*, and the leafhopper *Typhlocyba ulmi* and is transmitted chiefly by aphids. At least seven aphid species have been incriminated in experimental tests. Among the seven, *Myzus persicae* is most important, with *M. pseudosolani* and *M. circumflexus* in second place. One of the pathological aspects of leafroll is a necrosis of the phloem tissues of the potato plant, and this fact seems associated with the fact that the most efficient aphid transmitters habitually feed in the phloem.

After feeding on an infected plant, the aphid *M. persicae* requires several days before it is able to transmit leafroll, but after this period has elapsed it remains infective for a relatively long period of time. Apparently some biological relationship exists between the insect vectors and the leafroll virus.

Curly top of sugar beets, a disease historically important because its relationship to the leafhopper *Eutettix tenellus* was recognized before its virus nature was understood, presents an instance of still closer biological limitation between insect and virus. Although curly top virus can be transmitted artificially by sap inoculation, the only known means of transmission in nature is the beet leafhopper. This leafhopper is not known to transmit any other virus disease. Curly top virus overwinters in a number of wild plants, as well as in overwintered sugar beets Leafhoppers, feeding on these plants, become infected. The virus then requires an incubation period in the body of the insect, ranging from as short a time as twenty minutes to as long as seven hours, and the leafhopper is unable to transmit the disease until this period has elapsed. In plants a latent period of four to fourteen days is required before symptoms appear.

Curly top has been investigated extensively by a number of workers, who have determined numerous interesting and important facts bearing upon the interrelations of host, virus and insect. In affected plants the virus is localized in the phloem. Insects, when feeding, must reach the phloem to become viruliferous and to transmit the disease. In searching for phloem tissue, the insect seemingly is guided by the pH value of the tissues through which its feeding apparatus passes. Phloem tissue is said to have a pH value of 7.5, xylem a value of 6.2, and parenchyma a value of 6.0. Rickettsia-like microorganisms have been reported in the intestinal tract lining of infective leafhoppers but have not yet been discovered in the tissues of infected plants. In the body of the insect, curly top virus is apparently most abundant in the blood, from which it is most readily recovered; it can also be recovered from the salivary glands and the contents of the alimentary tract. The virus content of the insect decreases slowly as the insect feeds on uninfected plants, and the power of transmission may disappear after fifty-four days. Apparently the virus does not multiply in the body of the leafhopper, although it may survive the winter there. If a quantity of viruliferous juice is precipitated with an equal volume of 95 per cent alcohol, centrifuged, washed in 50 per cent alcohol, dried, and mixed with sufficient five per cent sugar solution to restore the original volume, the product may be fed to leafhoppers to make them viruliferous and able to infect healthy plants.

Besides these biological relationships, certain ecological aspects are of interest. The beet leafhopper is restricted to an arid climate, and the curly top disease, being restricted to one vector, is limited to the region occupied by the leafhopper. Sparse stands of Russian thistle provide optimum conditions for development of the leafhopper; high humidity in heavy stands checks development of the insect. In sugar beet fields, optimum conditions for the leafhopper obtain when the stand is poor or when the plants are small.

The virus the leafhopper transmits benefits its vector by contributing suitable environment. Sugar beet fields would be but little used by the leafhopper were it not for the effect of the curly top virus on the sugar beet plants.

Aster yellows and peach yellows are two additional virus diseases, research on which has yielded important knowledge of the relationship of plant pathogenic viruses and insect vectors. Aster yellows is an extremely destructive disease of cultivated asters and affects nearly 200 other species of plants in North America. It is transmitted exclusively by the leafhopper *Macrosteles divisa*. Both nymphs and adults are able to transmit the virus. However, incubation of the virus for at least ten days in the body of the insect is required before disease can be induced. Fully viruliferous leafhoppers, if held at a temperature of 31° C. or above for several days, become non-infective. Apparently the virus in the body of the insect is destroyed by prolonged heat. It is supposed that on this account spread of the disease is less during the hot weather of midsummer. If, however, the exposure of the insect to high temperature is of short duration, the virus is only partially inactivated and, after the elapse of a suitable period, may again become potent. Thus there is evidence of multiplication of the virus in the body of the insect.

Peach yellows, recognized for more than a hundred years as an extremely destructive disease of peaches, is transmitted only by the plum leafhopper, *Macropsis trimaculata*. It and aster yellows can be transmitted artificially only by grafting. The incubation period of the peach yellows virus in the leafhopper ranges from eight to 26 days. Both nymphs and adults are able to transmit the virus. The presence of intracellular inclusions has been demonstrated in the intestinal walls and salivary glands of viruliferous leafhoppers.

Taxonomic groups of insects vary greatly in importance as virus vectors, and the importance of different groups appears correlated with feeding methods. Grasshoppers, which have chewing mouth parts, transmit the spindle-tuber disease of potatoes, but are not specific transmitters. Thrips, which feed with a rasping-sucking action, transmit spotted wilt of tomato, pineapple yellow spot, and streak of peas, and some degree of specific biological relationship exists between them and these viruses. Aphids, which feed by sucking, are the most important of the virus vectors, both as to number of vectors and number of viruses transmitted. Thirty-six aphid species transmit 38 viruses. One aphid, *Mizus persicae*, transmits 19 viruses. Next in importance are leafhoppers, and it is in this group that the highest type of biologically obligatory association between virus and vector is found. Fifteen viruses are transmitted by 19 leafhopper species. But no leafhopper transmits two unrelated viruses, and no virus is transmitted by more than four leafhoppers. Scale insects and mealy bugs, though common on a wide range of plants, transmit few viruses. Two lacebugs transmit the viruses of two sugar beat diseases, and plantbugs, especially the tarnished plantbug, transmit viruses that are easily transmitted mechanically. Only a small number of beetles transmit viruses and in those few cases probably do so mechanically and without displaying any biological relationship.

Sucking insects are the most effective vectors of plant pathogenic viruses, but even among them there are great differences in ability to transmit. Some are unable to transmit any virus; others transmit certain viruses mechanically; and still others transmit only single viruses in such a way as to indicate the existence of very highly specialized adaptations between vector and virus.

PROBLEMS NEEDING INVESTIGATION

Although the rôle of insects as vectors of plant pathogens has been recognized in numerous instances, there still is need for clarification in this basic field. Insect vectors are unknown for 54 out of a total of 129 recognized virus diseases of plants. There are numerous opportunities for research in special aspects of the relationship between plant pathogens and their insect vectors. In the field of viruses, for example, it is important to learn why one aphid species can transmit 19 kinds of virus, while at the other extreme one leafhopper species can transmit just one kind of virus not transmitted by any other leafhopper species. It would be of interest to know what the incubation period of a virus in an insect body actually represents. It would be valuable

to trace the progress of a virus in an insect body from the time it is accepted until it is given back to a plant. An especially intriguing field of research has been opened up by the discovery that certain plant viruses appear as protein crystals. That discovery may furnish the key to the question, "What form does a virus take in the body of its insect vector?"

STATE OF ILLINOIS
DWIGHT H. GREEN, Governor

TRANSACTIONS

OF THE

ILLINOIS STATE ACADEMY OF SCIENCE

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ANNOUNCEMENTS

Authors submitting manuscripts for consideration by the publications committee of the 1943 Transactions must leave them with Section Chairmen on or before May 7th. These scripts must be in final form. They must be typed (double spaced) in dark ribbon, and should not exceed 1200 words in length (including tables and not more than one illustration if possible) unless special arrangements are made. (1200 words amounts to 2 printed pages, thus eliminating an extra-page fee and keeping to a minimum for the author the cost of reprints.)

Beneath title should appear author's name and, in a separate line, his school and/or town. At the end of article should appear the address to which proof is to be sent in August or September. If author will not be able to read proof, an alternate should be specified who will be responsible for reading it.

Inasmuch as the Academy does not have funds for preparing illustrations, all drawings, charts, and special formulae (chemists and physicists, please note) must be submitted in India ink, about twice the finished size desired. All photographs should be gloss prints (no photostats can be used), also larger than desired finished size. Mount each illustration on separate sheet, with title or figure typed beneath it.

Any author whose paper is published must be a member of the Academy ($1.00 annual dues payable to John Voss, Treasurer, Peoria, Illinois), and must pay an editorial fee of $1.00 when submitting paper, to help defray expenses of publication. Reprint prices and order blanks will be included with proof.

Authors are asked to send, if possible, brief abstracts of their articles to Grace Tickle, MacMurray College, Jacksonville, Illinois, immediately. If Section Chairmen already have these, please send at once to Miss Tickle, Publicity Chairman.

Requests for research grants from the A. A. A. S. are received each year up to April 24th and recipients announced at the May meeting. Chairman for the current year is L. H. Tiffany, Northwestern University, Evanston. Chairman for the ensuing year will be announced in the June issue of the Transactions.

State Physics Teachers Association, affiliated with the Academy, will meet with the Physics section Friday afternoon and Saturday morning.

Social Science group will meet at luncheon Friday. (See General Program).

SATURDAY MORNING TRIPS

(1) To the State School for the Blind; (2) To the State School for the Deaf; (3) To Jacksonville State Hospital.

Exhibits of work, explanation of operation, methods of teaching will be explained on these trips. Members and guests are urged to indicate their choice ahead of time because of the problems incident to arranging transportation.

SECTION CHAIRMEN

AGRICULTURE, O. L. Whalin, Dept. of Agriculture, Univ. of Illinois, Urbana.
ANTHROPOLOGY, Ben Nussbaum, Fairbury.
BOTANY, K. R. Johnson, National College of Education, Evanston.
CHEMISTRY, H. W. Gould, Northern Illinois State Teachers College, DeKalb.
GEOGRAPHY, L. A. Holmes, Department of Geography, State Normal, Normal.
GEOLOGY, W. E. Powers, Dept. of Geology, Northwestern Univ., Evanston.
PHYSICS, O. L. Railsback, East Illinois State Teachers College, Charleston.
PSYCHOLOGY and EDUCATION, M. R. Goodson, University H. S., Urbana.
SOCIAL SCIENCES, V. Dake Jolley, Wheaton College, Wheaton.
ZOOLOGY, H. H. Ross, Natural Resources Building, Urbana.

All Section Meetings will be held in the Science Building of MacMurray College.

GENERAL PROGRAM

ALL ADDRESSES AND SECTION MEETINGS OPEN TO THE PUBLIC

Jacksonville, Illinois, May 7-8, 1943

THURSDAY, MAY 6. 6:00 p. m. Council Dinner and Meeting. DUNLAP HOTEL.

8:00 a. m. *Registration* by all members and guests. Securing of Final Programs, tickets for annual banquet, registration for Saturday visits. *Tanner Memorial Library, Illinois College.*

8:45 a. m. *Preliminary business meeting* of the Academy for all members. Appointment of nominations, resolutions and auditing committees. *Jones Chapel, Illinois College.*

9:30 a. m. *General Session. Jones Chapel, Illinois College.*

Welcome by H. Gary Hudson, President of Illinois College, and Clarence P. McClelland, President of MacMurray College. Academy Presidential Address: "American Science in the Development of the Phillipines," F. M. Fryxell, Augustana College, Rock Island.

Lecture: "Our Natural Heritage, its Benefits and its Menace," Dr. Edson S. Bastin, Department of Geology, University of Chicago, Chicago.

12:30 *General Luncheon. MacMurray College.* 65 *cents.*

Mail reservation to Willis DeRyke, Illinois College, Jacksonville, Illinois by May 1.

Social Science Luncheon. Dunlap Hotel, Mayfair Room. 75c cents.

1:30-4:30 *Section Meetings. MacMurray College, Science Building* class rooms and lecture rooms. All papers, to be considered for publication, must be given to Section Chairmen by the end of this session. See Announcements page for specifications.

Junior Academy of Science Club "Aids" from the Illinois State Museum on display in room 5, MacMurray Hall Science Building.

5:00-5:30 *Annual Business Meeting* for all members of the Academy. *Room* 17, MacMurray College Science Building.

6:30 p. m. Annual Banquet for Senior Academy, Collegiate Section, and guests. *Dunlap Hotel.* $1.25. Informal. Announcements of A. A. A. S. research awards. *Mail reservations to Willis DeRyke, Illinois College, Jacksonville, Illinois by May* 1. Call for tickets by 10:30 a. m. May 7, at Registration Desk.

8:15 p. m. *Annual Lecture* for everyone attending Academy sessions and for the general public. "National Parks During the War and in the Future," illustrated, by Carl P. Russell, Head of the Department of Research and Interpretation of the National Park Service. *High School auditorium.* A special section will be reserved for those attending the Academy banquet.

SATURDAY, MAY 8

8:45 a. m. *Meeting of the Council for* 1943-44. *Dunlap Hotel.*

9:30 a. m. *Annual Trips.* Three trips, all within Jacksonville, have been arranged. A tour of the plants and demonstrations of methods of teaching the State's handicapped children will be conducted at the State School for the Blind and the State School for the Deaf; the third will be to the State Hospital for the Insane. *Please indicate choice by May* 1. *Reservation blanks in this issue.*

AGRICULTURE—ROOM 16

Chairman: O. L. Whalin, University of Illinois, Urbana.

Election of Chairman for 1943-44.

1. Wood Helps to Win the war.
   J. E. Davis, University of Illinois, Urbana.
2. The Rural War Production Training Program.
   R. D. Eiler, Jacksonville H. S.
3. Effect of Soil on Plant Nutritive Content.
   H. J. Snider, University of Illinois, Urbana.
4. Improving the Quality of Roughage as an Aid to Wartime Feeding of Dairy Cattle.
   W. B. Nevens, University of Illinois, Urbana.
5. Agricultural Extension Program Meets Wartime Needs.
   W. F. Coolidge, Farm Adviser, Jacksonville.
6. Meeting Wartime Production While Maintaining Fertility in Southern Illinois.
   C. J. Badger, University of Illinois, Urbana.
7. Credit Agency Adjustments for Wartime Needs.
   H. S. Whalin, Federal Land Bank, St. Louis, Mo.
8. Making Pastures Contribute Their Share to Food Production.
   G. C. Hanson, U. S. Soil Conservation Service.
9. Cutting Corners in Wartime Livestock Production.
   E. T. Robbins, University of Illinois, Urbana.

Turn papers in to Chairman

ANTHROPOLOGY—ROOM 29

Chairman: Mr. Ben Nussbaum, Fairbury, Illinois.

Election of Chairman for 1943-44.

1. Title to be announced.
   Fay-Cooper Cole, University of Chicago, Chicago.
2. Aims and Methods of Archaeology.
   John C. McGregor, Springfield.
3. A Method for Mound and Mound Group Determination in the Wisconsin Glaciation of Central Eastern Illinois.
   John B. Ruyle, Champaign.
4. An Illinois Corner-Tang.
   C. W. Hudelson, Normal.
5. Who were The Prehistoric Peoples of Illinois?
   Harry L. Spooner, Peoria.
6. The Arrowsmith Battlefield.
   William B. Brigham, Bloomington.
7. Prehistoric Indian Mounds in Central and Eastern Illinois and Their Excavations.
   Francis Lowry, Champaign.
8. The Illinois Confederacy and The Middle Mississippi Culture in Illinois.
   Donald E. Wray and Hale Smith, University of Chicago.
9. The Prehistoric Indian in Calhoun County.
   Rev. George M. Link, Michael.
10. Exit, The Red Man; Enter, The White Man.
    C. C. Burford, Urbana.

Turn papers in to Chairman

BOTANY—ROOM 7

Chairman: K. Richard Johnson, National College of Education, Evanston

Election of Chairman for 1943-44.

1. A possible explanation of the origin of preclimax prairies.
   Blanche McAvoy, Illinois State Normal University, Normal.
2. Cellular Versus Organismic Physiology of the Vitamins.
   F. L. Wynd, Urbana.
3. Applied Botany as Fun.
   Neil E. Stevens, Urbana.
4. The Use of Prairie Relics in Teaching.
   L. Wallace Miller, Normal.
5. Oedogonia from Southern Florida.
   L. H. Tiffany, Evanston.
6. A New Mucor-like Fungus from Plant Roots.
   L. H. Tehon, Urbana.
7. A Preliminary Check List of the Plants of Sangamon County, Illinois.
   Geo. D. Fuller, Springfield.
8. Preliminary Report on Bryophytes of Bois Blanc Island.
   Opal C. Hartline, Normal.
9. Total Nitrogen and Vitamin C in Oats Grown at Different Levels of Soil Moisture.
   Glenn R. Noggle, Urbana.
10. The Genus *Viola* in Illinois.
    G. Neville Jones, Urbana.
11. The Older Forest Plantations of Illinois.
    J. Nelson Spaeth, Urbana.
12. Natural Reforestation in Strip Mines of Salem County, Illinois.
    Clarence Bonnell, Harrisburg.

Turn papers in to Chairman

CHEMISTRY—ROOM 17

Chairman: H. W. Gould, Northern Illinois State Teachers College, DeKalb

Election of Chairman for 1943-44.

1. Some New Sources of Aluminum and Magnesium.
   B. S. Hopkins, Urbana.
2. Perchloric Acid—A Neglected Chapter in General Chemistry.
   J. H. Reedy, Urbana.
3. Inulin-Containing Plants as a Source of Ethyl Alcohol.
   D. T. Englis and L. F. Szerlong, Urbana.
4. Some Observation of The Influence of Sodium Carbonate in Water Supplies.
   H. W. Adams, Normal.
5. A Comparison Between Small and Large Group Instruction in the Teaching of the Physical Sciences.
   N. D. Cheronis, Chicago.
6. Determination of Magnesium.
   I. J. Jenks, DeKalb.

7. Certain Vitamin Requirements of Bacteria.
   F. M. Clark, Urbana.
8. The Determination of Chlorates in The Presence of Perchlorates.
   G. F. Smith, and A. J. Veraguth, Urbana.
9. Illinois Fluorspar in the War Effort.
   G. C. Finger, Illinois Geological Survey, Urbana.
10. Illinois Minerals as Chemical Raw Materials.
    F. H. Reed, Illinois Geological Survey, Urbana.

Turn papers in to Chairman

GEOGRAPHY—ROOM 22

Chairman: Geography: L. A. Holmes, State Normal University, Normal
Election of Chairman for 1943-44.

1. The Place of Geography in the Field of Aeronautics. (With Slides).
   Harry L. Adams, Bloomington.
2. The Baltic Sea.
   W. O. Blanchard, Urbana.
3. A Phase of Geography in the Sudbury Area.
   Thomas F. Barton, Carbondale.
4. Pre-War Truck Movement of Coal From Illinois Mines.
   Leslie A. Holmes, Illinois State Normal University, Normal.

Turn papers in to Chairman

GEOLOGY—ROOM 4

Chairman: William E. Powers, Northwestern University, Evanston.
Election of Chairman for 1943-44.

1. The program of oil well logging of the Illinois Geological Survey.
   G. H. Cady, Illinois Geological Survey, Urbana.
2. The use of electric logs in the interpretation of the Pennsylvanian succession in Illinois.
   M. W. Pullen and Paul K. Sims, Illinois Geological Survey, Urbana.
3. Shallow coal resources of Wabash County.
   J. M. Schopf, Illinois Geological Survey, Urbana.
4. The structure of the Millersville limestone in Shelby and Cumberland Counties.
   E. F. Taylor, Illinois Geological Survey, Urbana.
5. Pennsylvanian stratigraphy of eastern Vermilion County, Illinois, and an adjacent area in Indiana.
   J. W. Alexander, University of Illinois, Urbana.
6. Pennsylvanian stratigraphy of the Carlinville, Illinois, quadrangle.
   J. R. Ball, Northwestern University, Evanston.
7. A Microfossil Profile of Certain Pennsylvanian Coals of Ohio.
   R. M. Kosanke, Illinois Geological Survey, Urbana.
8. Place of Geology and Geography in the War.
   Harold W. Scott, University of Illinois, Urbana.
9. War Time Course in the Interpretation of Maps and Aerial Photographs.
   Harold R. Wanless, University of Illinois, Urbana.
10. Bedrock Surface and Thickness of Glacial Drift in Will County, Illinois.
    Leland Horberg and A. C. Mason, Illinois Geological Survey, Urbana.

11. Buried Bedrock Valleys East of Joliet and Their Relation to Water Supply.
Leland Horberg and K. O. Emery, Illinois Geological Survey, Urbana.
12. Progress in the Wisconsin Zinc District.
C. H. Behre, Jr., and A. F. Agnew, U. S. Geological Survey.
13. Comparative Study of the Quartz Pebbles in the Lafayette Gravel and Caseyville Conglomerate of Southern Illinois.
Robert R. Reynolds, Illinois Geological Survey, Urbana.
14. Insoluable Residues of the Rosiclare, Levias and Renault Formations of Hardin County, Illinois.
Frank E. Tippie, Illinois Geological Survey, Urbana.
15. Post-Wisconsin Chronology.
Don L. Carroll, Illinois Geological Survey, Urbana.

Turn papers in to Chairman

PHYSICS—ROOM 11

Chairman: O. L. Railsback, Eastern Illinois State Teachers College, Charleston

Election of Chairman for 1943-44.

The I. A. A. P. T. is meeting jointly with the Academy section. The program this year will encompass a Round Table discussion of problems arising out of the war effort. Details later.

SOCIAL SCIENCE AND PSYCHOLOGY AND EDUCATION
Joint Session—Room 25

Chairman: *Psychology and Education*: M. R. Goodson, University H. S., Urbana.
Social Sciences: V. Dake Jolley, Wheaton College, Wheaton.

12:30 Luncheon. Address: "Wanted: A West Point for Peace Leadership."
Sylvanus M. Duvall, George Williams College.

2:30 *Election of Chairmen for* 1943-44.

1. Liberal Arts Education in the Time of War.
H. Gary Hudson, Illinois College, Jacksonville.
2. Guidance Problems in War Time.
Wendell S. Dysinger, MacMurray College, Jacksonville.
3. The Sociological Theories of Cournot and Pareto Examined in the Light of World Conditions Today.
Grace M. Jaffe, Barat College, Lake Forest.
4. Vice and Juvenile Delinquency in Defense Areas in Rock Island County.
A. F. Schersten, Augustana College, Rock Island.
5. The Poverty-Line and Wartime Policy.
W. Hardy Wickwar, Rockford College, Rockford.
(Discussion of Papers 3, 4, and 5, conducted by Joe Patterson Smith, Illinois College, Jacksonville.)

Saturday morning. "The Effects of Social Climates on Behavior," a motion picture showing procedure and results of experiments in autocracy, democracy, and *laissez-faire* types of social organization performed by Lewin and others at University of Iowa. Implications for classroom management of interest to psychologists as well as teachers of social science because of method of research involved and results obtained.

Turn papers in to Chairman

ZOOLOGY—ROOM 12

Chairman: H. H. Ross, Illinois Natural History Survey, Urbana
Election of Chairman for 1943-44.

1. Rare and Extinct Birds in the Collections of the Illinois State Museum.
   Gilbert Wright, Illinois State Museum, Springfield.
2. A Neglected Function of Biologists.
   W. V. Balduf, University of Illinois, Urbana.
3. An Unusual Case of a Sexually Mature Trematode From the Body Cavity of a Diving Beetle.
   W. W. Crawford, Blackburn College, Carlinville.
4. Notes on the Sudden Mortality of Yellow Bass.
   D. F. Hansen, Illinois Natural History Survey, Urbana.
5. The Removal of Parasites from Fowl Hosts by Means of Starvation.
   W. M. Reid, Monmouth College, Monmouth.
6. The Life Cycle of a New Diphyllobothrium Tapeworm from the Herring Gull.
   L. J. Thomas, University of Illinois, Urbana.
7. Some Notes on the Natural History of Reelfoot Lake, Tennessee.
   C. C. Hoff, Quincy College, Quincy.

Turn papers in to Chairman

COLLEGIATE SECTION—ROOM 23

Papers and Demonstrations by Undergraduate College and University Students

Chairman: Mrs. Martha Leavenworth, University of Illinois.
Preliminary Business Meeting.

1. Plant Pigments and Plastids.
   Marijane Anderson, Rosary College, River Forst.
2. Prevalence of Typhoid Fever in Illinois—1935-1941.
   Ada Jeanne Thomas, College of St. Francis, Joliet.
3. The Heredity of Myopia, (15 min.—Lantern slides).
   E. Antzis, Loyola University, Chicago.
4. Genetics and Pre-medics.
   Dorothy Tatter, Rosary College, River Forest.
5. The Effects of Low Pressures on Colon Activity in the Dog.
   J. A. Frymire, University of Illinois, Urbana.
6. The Effect of Nicotine on Pregnant Mice and Their Offspring, (15 min.—Lantern Slides).
   Arthur T. Janecke, Loyola University, Chicago.
   Kenneth J. Fitzgerald, Loyola University, Chicago.
7. Nutritive Content of Fruit Juices, and Methods of Determination.
   A. Vitamin C, Edith Walder, College of St. Francis, Joliet.
   B. Minerals, Georgene Pranger, College of St. Francis, Joliet

8. The Use of Alizarin Stain for a Microscopic Study of Bone Development in the Chick.
   M. Vruno, Loyola University, Chicago.
9. Further Studies on the Cardiac Frequency of the Chick Embryo, (15 min.—Lantern Slides).
   R. DeSalvo, Loyola University, Chicago.
   M. Kralicke, Loyola University, Chicago.
   A. Sowka, Loyola University, Chicago.
10. The Effects of Janus Green B. upon the Respiration and Potential of Frogs.
    W. A. Teppert, University of Illinois, Urbana.
11. Electrolytic Polishing of Metals for Metallographic Examination.
    John A. Bell, University of Illinois, Urbana.
12. Some Physical Properties of Powdered Iron Compacts.
    Frank A. Rough, University of Illinois, Urbana.
13. Geological Study of Aerial Photographs in the Uinta Mountains, Utah.
    William Oesterling, University of Illinois, Urbana.
14. Correlations of the Mississippian in Alaska and Canada.
    Dorothy Johnson, University of Illinois, Urbana.
15. Stratigraphic Studies on the Mississippian of the Rocky Mountains.
    Earl Cockrum, University of Illinois, Urbana.

GENERAL INFORMATION

Headquarters

Headquarters for the Academy Friday forenoon will be in Tanner Memorial Library Building, Illinois College.

Messages sent previous to registration and until noon of Friday, May 7, should be addressed in care of Willis DeRyke, Illinois College, Jacksonville, Illinois. After noon Friday, May 7, messages will be received at MacMurray college.

Transportation

Railroads: Alton; Chicago, Burlington and Quincy; Wabash. At present the Alton R. R. has two trains each way daily. The Burlington and Wabash each has one train each way daily.

Buses: Greyhound between Chicago and Kansas City. Jacksonville Trailways between Peoria and St. Louis and between Springfield and Hannibal and Quincy.

Room Accommodations

Those who desire hotel accommodations should communicate directly with the hotels.

The Dunlap Hotel

Single room without bath (with Toilet and Lavatory)	$1.75, $2.00, $2.50
Single room with bath	$2.50, $2.75, $3.00, $3.50
Double room without bath (with Toilet and Lavatory) (double bed)	$2.75, $3.00, $3.50
Double room with bath, double bed	$3.50, $3.75, $4.00, $4.50
Double room with bath, twin beds	$4.50, $5.50

The Pacific Hotel

Single room without bath (lavatory only)	$1.00, $1.25
Double room without bath, double bed	$1.50, $1.75
Double room with bath, double bed	$2.00, $2.50

Rooms in private homes may be arranged for in advance of the meeting by communicating with Willis DeRyke, Chairman of Arrangements, Illinois College, Jacksonville, Illinois.

Meals

Luncheon and banquet reservations should be made in advance, so that tickets may be obtained at the registration desk in Tanner Memorial Library Building Friday forenoon, May 7.

Inspection Trips

There are three inspection trips. They will start from the Dunlap Hotel promptly at 9:30 a. m. Saturday. Those expecting to go on these trips should make reservations in advance if possible and verify these at the time of registration on Friday.

RESERVATIONS*

For

ILLINOIS ACADEMY OF SCIENCE MEETINGS

Jacksonville, Ill., May 7-8, 1943.

Return to Willis DeRyke, Illinois College, Jacksonville, Ill. by May 1
Please reserve rooms in private rooming house for (list names):

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Friday night----------

Saturday night----------

Signed----------

Please reserve tickets for the following meals:

	Number Desired
Regular Academy luncheon	----------
Regular Academy banquet	----------
Social Science luncheon	----------

Signed----------

Please indicate which Saturday trip you expect to make:

Trip to State School for the Blind	----------
Trip to State School for the Deaf	----------
Trip to Jacksonville State Hospital	----------

Signed----------

*PLEASE SEND IN YOUR RESERVATIONS BY MAY 1st. Mr. DeRyke asks your cooperation in this to avoid confusion in the food and transportation plans which must be worked out for the meeting in advance. There will be a limited number of reservations available on May 7.

STATE OF ILLINOIS
Dwight H. Green, Governor

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Transactions

of the

ILLINOIS STATE ACADEMY OF SCIENCE

Volume 35 June, 1943 Number 4

Reports Concerning the Thirty-sixth Annual Meeting, Jacksonville, Illinois, including Collegiate Section Consitution May, 1943

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STATE OF ILLINOIS
DWIGHT H. GREEN, *Governor*

DEPARTMENT OF REGISTRATION AND EDUCATION
FRANK M. THOMPSON, *Director*

ILLINOIS STATE MUSEUM DIVISION
JOHN C. MCGREGOR, *Acting Chief*

ILLINOIS ACADEMY OF SCIENCE
AFFILIATED WITH THE
ILLINOIS STATE MUSEUM

OFFICERS FOR 1943-1944

President: L. J. THOMAS
University of Illinois, Urbana

First Vice-President: A. E. EMERSON
University of Chicago, Chicago

Second Vice-President: H. W. GOULD
Northern Illinois State Teachers College, DeKalb

Secretary: L. R. TEHON
Illinois Natural History Survey, Urbana

Treasurer: John Voss
Manual Training High School, Peoria

Librarian: GILBERT WRIGHT
Illinois State Museum, Springfield

Collegiate Section Coordinator: H. R. WANLESS, University of Illinois, Urbana
Junior Academy Representatives: To be named later

Editor: GRACE NEEDHAM OLIVER
Illinois Geological Survey, Urbana

In addition to current officers, the Academy Council for 1943-4 includes the two most recent past presidents: F. M. FRYXELL, *Augustana College*, Rock Island and T. H. FRISON, *Illinois Natural History Survey*, Urbana.

1944 MEETING AT DE KALB, MAY 5-6

COMMITTEE ON LOCAL ARRANGEMENTS

H. W. GOULD, *Chairman*, Northern Illinois State Teachers College, DeKalb

PAUL STREET, *Publicity Chairman*, Northern Illinois State Teachers College, DeKalb

G. L. TERWILLIGER, *Collegiate Section Chairman*, Northern Illinois State Teachers College, DeKalb

W. H. BEAUMONT, *Junior Academy Chairman*, DeKalb Township High Shcool, DeKalb

Printed June, 1943

TRANSACTIONS OF THE ILLINOIS STATE ACADEMY OF SCIENCE
Volume 34 June, 1943 Number 4

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SECTION CHAIRMEN FOR 1943-44

Agriculture:	C. J. Badger, Illinois Agricultural Experiment Station, Mt. Vernon.
Anthropology	Donald E. Wray, 604 Caroline St., Peoria.
Botany	L. Wallace Miller, Illinois State Normal University, Normal.
Chemistry	C. W. Bennett, Western Illinois State Teachers College, Macomb.
Geography	Harry L. Adams, Bloomington High School, Bloomington.
Geology	A. H. Bell, Illinois State Geological Survey, Urbana.
Physics	K. G. Larson, Augustana College, Rock Islaud.
Psychology and Education	Marion Stewart, MacMurray College, Jacksonville.
Social Science	W. Hardy Wickwar, Rockford College, Rockford.
Zoology	Charles S. Spooner, Department of Biology, Eastern Illinois State Teachers College, Charleston.
Collegiate Section	H. R. Wanless, Coordinator, University of Illinois, Urbana.

DELEGATES AND COMMITTEES FOR 1943-44

Delegate to *A. A. A. S.:* R. F. Paton, University of Illinois, Urbana.
Delegate to *Conservation Council:* V. O. Graham, 4028 Gract St., Chicago.

Committee on Conservation:

M. M. Leighton, Chairman, Illinois Geological Survey, Urbana.
W. H. Haas, Northwestern University, Evanston.
N. M. Gersbacher, Southern Illinois Normal University, Carbondale.
D. D. Lansden, Cairo.
Paul Houdek, Robinson High School, Robinson.
George Bennett, Illinois Natural History Survey, Urbana.
R. S. Smith, University of Illinois, Urbana.
W. C. Allee, University of Chicago, Chicago.
E. L. Stover, Eastern Illinois State Teachers College Charleston.
Rev. G. M. Link, Grafton.
C. P. Russel, National Park Service, Chicago.
H. L. Shantz, U. S. Forest Service, Chicago.

Committee on Legislation and Finance:

Fay-Cooper Cole, Chairman, University of Chicago, Chicago.
H. B. Ward, University of Illinois, Urbana.
F. W. Aldrich, 1506 East Washington Street, Bloomington.
E. S. Bastin, University of Chicago, Chicago.

Committee on Affiliations:

H. R. Wanless, Chairman, University of Illinois, Urbana.
I. P. Daniel, Lake View High School, Chicago.
V. F. Swaim, Bradley Polytechnic Institute, Peoria.
Glen Warner, 7633 Calumet Avenue, Chicago.
H. D. Gloyd, Chicago Academy of Sciences, Chicago.
Mrs. Geraldine Nilson, Elmhurst College, Elmhurst.
Percival Robertson, The Principia College of Liberal Arts, Elsah.

Committee on Membership:

J. E. Coe, Chairman, 2024 Sunnyside, Chicago.
J. H. Reedy, University of Illinois, Urbana.
N. D. Cheronis, 5556 Ardmore Avenue, Chicago.
J. F. Stanfield, Chicago Teachers College, Chicago.
G. E. Ekblaw, Illinois Geological Survey, Urbana.
Floyd Barloga, 1423 North Glen Oak, Peoria.
G. W. Hufford, 116 Sesser, Joliet.
W. B. Welch, Southern Illinois Normal University, Carbondale.
D. L. Eaton, Northern Illinois State Teachers College DeKalb.
K. G. Larson, Augustana College, Rock Island.
Orlando Park, Northwestern University, Evanston.
G. N. Jones, University of Illinois, Urbana.
Fred R. Cagle, Carbondale.
Carl Ekblad, Moline High School, Moline.

Committee on Conservation of Archaeological and Historic Sites:

Fay-Cooper Cole, Chairman, University of Chicago Chicago.
F. W. Aldrich, 1506 East Washington, Bloomington.
M. J. Herskovits, Northwestern University, Evanston.
M. M. Leighton, Illinois Geological Survey, Urbana.
J. B. Ruyle, 201 South Fair, Champaign.
H. B. Ward, University of Illinois, Urbana.
Bruce W. Merwin, Carbondale.

Committee on Research Grants from A.A.A.S.:

Carl G. Hartman, Chairman University of Illinois, Urbana.
J. R. Ball, Northwestern University, Evanston.
O. L. Railsback, Eastern Illinois State Teachers College, Charleston.
B. S. Hopkins, University of Illinois, Urbana.
R. O. Freeland, Northwestern University, Evanston.
N. M. Gersbacher, Southern Illinois Normal University, Carbondale.

Committee on Budget:

C. L. Furrow, Knox College, Galesburg.
John Voss, Manual Training High School, Peoria.
W. H. Voskuil, Illinois Geological Survey, Urbana.

Committee on Publications:

The President.
The Secretary.
Neil E. Stevens, University of Illinois, Urbana.
H. J. Van Cleave, University of Illinois, Urbana.

Committee on Ecological Bibliography:

A. G. Vestal, University of Illinois, Urbana.

Committee on Teacher Training:

E. L. Stover, Chairman, Eastern Illinois State Teachers College, Charleston.

Committee on Pre-Medical Training:

C. T. Reid, Chairman, University of Illinois College of Medicine, Chicago.

1944 MEETING: DE KALB, MAY, 5-6

REPORTS OF COUNCIL MEETINGS, 1942-1943

The first council meeting was called to order by President Fryxell at 9:00 A.M. May 9, 1942, in room 132, Natural Resources Building, Urbana. The minutes of the last meeting were read and approved. Those present were T. H. Frison, F. M. Fryxell, John Voss, Mrs. G. N. Oliver, J. S. Ayars and R. F. Paton.

The main business of the meeting was concerned with checking the reports of the various committees and going over the list of officers and committees for next year to be sure that everything was in order for the new administration. A tentative report from the chairman of the collegiate section indicated that this new activity of the Academy at the annual meeting had been highly successful and the appointment of a committee to make plans for the next year was postponed as a special order of business for the November council meeting. The secretary was instructed to inform the groups at Jacksonville, Illinois, that the Academy had voted unanimously to accept their cordial invitation to hold the next annual meeting of the Academy there. The secretary was also instructed to send a sincere vote of thanks to the other groups who had asked to sponsor the Academy meeting, pointing out to them that there were two main reasons why the Jacksonville invitation was accepted instead of their own, one being that the Academy had never met at Jacksonville and it was felt that this would be an interesting place to hold the meeting. The other reason was that Jacksonville is fairly centrally located in the State, and since transportation may be difficult next year, it was felt that the central location was more desirable.

The appointment of a second vice-president was postponed also until the November meeting, awaiting recommendations from Jacksonville for this very important position.

The second council meeting was called to order at 10:30 A.M. by vice-president L. J. Thomas in the council room of the Natural History Survey, Natural Resources Building, Urbana, on November 7, 1942. President Fryxell had sent a telegram stating he would be delayed until noon on account of train connections from Washington, D. C. Members of the council present were T. H. Frison, V. O. Graham, A. R. Moore, R. F. Paton, L. J. Thomas, and John Voss.

Minutes of the May meeting were read and approved

Reports of the officers showed that the Academy had a cash balance in the treasury, that the publications were only slightly delayed by war conditions, and that only a few vacancies in the committees and section chairmanships were to be filled. After careful discussion, O. L. Railsback was appointed chairman of the Physics Section, M. R. Goodson chairman of the Psychology and Education Section, and H. H. Ross chairman of the Zoology Section.

Mrs. Martha Leavenworth reported that plans for continuance of the Collegiate Section were being formulated. After some discussion, the council named Professor H. R. Wanless coordinator for this group for the current year.

There was some discussion of the advisability of abandoning plans for the meeting at Jacksonville, but it was agreed that the importance of increased scientific activity more than justified the extra effort needed. President Fryxell, who arrived in time to take part in the discussion, said that national authorities felt state meetings should be continued and most state academies were going ahead with their plans. On motion it was voted unanimously to proceed with plans for the Jacksonville meeting in May. It was suggested that if possible a speaker be obtained for the annual public lecture, competent to discuss the direction which the effort of our academy group should take in the war.

The committee on premedical training was named and the secretary was instructed to ask Dr. C. I. Reed of the University of Illinois College of Medicine.

In line with the resolution voted at the annual business meeting, the council appointed a committee to make plans for the symposium on premedical training as suggested. Professor H. J. Van Cleave was elected as chairman of this committee with instructions to recommend a complete committee to the president for election at the council meeting in November. The name of Victor Johnson was also suggested for this committee.

The resolution from the physics section requesting that the Academy appoint a committee to work with the National Cooperative Committee on training for science teachers in the secondary schools was received and the council voted to establish this committee, suggested membership of which included the president of the high school chemistry teachers, John Coe of Chicago, J. Neckers of Carbondale, P. Houdek of Robinson, R. F. Paton of Urbana, with O. L. Railsback of Charleston as chairman. The secretary was instructed to notify Professor Railsback of this action, and to request him to accept the post as chairman.

The work of maintaining and increasing the sustaining membership of the Academy was assigned to another special committee with Ildrem Daniels of Chicago acting as chairman and the secretary and treasurer as ex-officio members. It was suggested that the local clubs of the State might well be informed of the program of the Junior Academy and be encouraged to support actively the work as a stimulus to increasing the interest in science training, the need for which is so important in the present emergency.

The time for the next council meeting was discussed and it was voted that the secretary should be instructed to call this meeting in Urbana at the time of the next high school conference. Dr. Frison invited the group to meet in his office. The time suggested was 10.00 A.M. The plan for a February meeting at Jacksonville was also discussed. The meeting adjourned at 10:30 A.M. to take the lead in calling the group together A. Carlson, C. I. Reed, B. V. Hall and I. C. Ivey were suggested as members of this committee.

A. R. Moore reported that the Junior Academy had decided not to hold a project competition in Jacksonville on account of anticipated transportation difficulties for many of the high school groups. A plan for local demonstrations and awards was outlined, together with an essay competition to assist in selecting recipients of the American Association for the Advancement of Science awards. The council agreed to cooperate in the judging. It was also agreed that the winning essays should be submitted to the editorial committee for publication in the Academy Transactions. The council also agreed to aid the Junior group in purchasing suitable insignia of membership. It was voted to authorize the treasurer to advance the necessary funds to purchase the pins selected, the treasury to be reimbursed from funds secured from the sale of the pins at cost.

The council adjourned at 12:15 for luncheon at the Illinois Union, further business being taken up during the luncheon.

L. J. Thomas reported on his work with the advisory committee on the Science Clubs of America. It was voted unanimously to recommend that cooperation with the Science Clubs of America be limited to servicing the Junior Academy clubs.

The secretary was instructed to request section chairmen to plan programs looking toward their usefulness in the war effort.

Meeting adjourned at 2:00 P.M.

The third council meeting was called to order February 20, 1943 at 2:00 P.M. at the Dunlap Hotel, Jacksonville, Illinois. W. A. De Ryke, Miss Helen Kamm, J. C. McGregor and R. F. Paton, O. L. Railsback, H. H. Ross, L. J. Thomas, Miss Grace Tickle, John Voss, and Gilbert Wright were present. President Fryxell being unable to leave his work in Washington, vice president Thomas presided.

Minutes of the previous meeting were read and approved.

The main business of the day was checking arrangements for the annual meeting of the Academy to be held in Jacksonville on May 7 and 8, 1943. A letter from President Fryxell outlining the program for the general sessions of the Academy was read. The council agreed that this part of the program was excellent. The representatives of the sponsoring colleges, MacMurray College and Illinois College, discussed arrangements with the council, and excellent facilities seemed to be available.

The treasurer, John Voss, reported a balance of $984.82 to provide for expenses of the meeting, such as publishing programs, postage, and similar items.

Most of the section chairmen reported through the secretary, and plans seemed well advanced with interesting programs already planned.

The Collegiate Section report was not encouraging. Transportation difficulties and distraction due to the war seemed to have prevented any general interest among undergraduates. The council agreed that any papers submitted could be scheduled with the regular sections, but asked the committee on local arrangements to provide a room where any delegates who might be able to attend could meet to discuss plans for the future.

Dr. De Ryke presented the plans for transporting and housing those attending the meetings. Excellent hotel accomodations were available and trains on the Alton, Burlington, and Wabash railroads, as well as bus service, provided ample transportation possibilities.

A letter from Sam Woodley was read, announcing that the grant for research for the Academy awards from the American Association for the Advancement of Science was $210.00 for 1943. It was pointed out also that this sum was 10 per cent of the dues paid by Academy members and amounted to 50 per cent of the annual dues to the state academy. Hence any member of the American Association for the Advancement of Science who joined the State Academy would be contributing a sum equal to half of his dues to the state organization to promote research in the state.

Dr. McGregor pointed out that, due to delays in publishing the December issue of the Transactions, the printing bill for this number was larger than would otherwise have been the case and the Museum had had to advance nearly $200.00 out of its own funds for this reason, in order to make the publication possible at all. He informed the council that postal authorities might also insist on the Academy forfeiting its bond guaranteeing the regular quarterly issue of the Academy publications for mailing. The finance committee of the Academy had been cooperating individually, he said, and it was hoped that the usual support from the state for the Academy publications could be secured. He urged that every effort be made to bring out the publications promptly.

A report from the editor showed that considerable difficulty had been experienced in getting proof back from the authors due to the many changes in address arising from war conditions.

Mr. Wright, the librarian, asked that he be given the privilege of furnishing a few reprints, in demand by research agencies in industry in connection with the war effort, from extra copies of the Transactions where available. It was moved, seconded, and voted to grant the librarian this privilege, provided extra copies of the Transactions were available.

To assist the editorial committee of the Academy in making a consistent decision on charges for publishing symposium papers, the council was asked to determine the policy. After some discussion, it was voted to charge the authors the same page fee as charged to all authors submitting papers for publication. Section chairmen, it was felt, should feel free to ask for invited papers for publication only if each chairman instructed the authors concerning the necessary charges which the Academy would have to make due to the limited funds.

A. R. Moore submitted a report for the Junior Academy. Plans for local competition were being worked out and received with good spirit in most cases and some enthusiasm in many localities. The Junior groups were naturally disappointed in not being able to come to the state meeting. Pins for the Junior Academy clubs were now available, and club charters and certificate awards were being provided.

L. J. Thomas reported further work with the American Association for the Advancement of Science committee on cooperation with the Science Clubs of America. He felt that the plan worked out by the Virginia Academy was sensible, and after some discussion the council voted to reocmmend to the council of the Junior Academy that it draw up a plan for a two-way membership in the Junior Academy and the Science Clubs of America. It was pointed out that the Junior Academy clubs should still use their own pins and that any contributions to the Science Clubs of America should be optional on the part of the Junior Academy. Dr. Thomas felt such a plan would still be acceptable to the governing board of the Science Clubs of America.

A nominating committee consistlng of T. H. Frison, G. D. Fuller, H. K. Gloyd, V. O. Granam, E. L. Stover and Gilbert Wright was named by the council.

The meeting adjourned at 5:00 P.M.

The fourth council meeting was called to order May 6, by President Fryxell in the Hotel Dunlap, Jacksonville, Illinois, at 7:00 P.M. Members of the council present were F. M. Fryxell, L. J. Thomas, W. DeRyke, J. Voss, G. Wright, A. R. Moore, R. F. Paton, and Mrs. G. N. Oliver. Also attending were special officers of the Academy and guests who were assisting with the details of the annual meeting: Miss Grace Tickle, Miss Helen Kamm, E. S. Bastin, W. F. Bailey, E. Hildner, L. R. Tehon, M. R. Goodson, J. Aggar, and E. C. Rutherford.

Minutes of the previous meeting were read and approved.

Dr. DeRyke, second vice-president and chairman of the local arrangements committee, reported that plans were laid, facilities provided and all arrangements for the meetings scheduled for Friday and Saturday in order. Final details were discussed and it was plain that all the needs had received careful consideration.

Brief reports from the treasurer, Dr. John Voss, and the editor, Mrs. G. N. Oliver, were received and after brief discussion approved. Finances of the Academy were in sound condition and the editor was making continued effort to keep the publications prompt, though war conditions had led to some unavoidable delays.

Personnel for the committees to be appointed Friday were discussed and names suggested.

Junior Academy affairs in the experienced hands of A. R. Moore were reported. Mr. Moore told the council briefly how club awards had been worked out and stated that suitable insignia at a very reasonable price had been obtained. The meeting with the senior Academy in 1943 had been impossible because of transportation limitations, but exhibits and meetings were being held in local areas, with judging and awarding of prizes.

Dr. L. J. Thomas made a brief statement on the plans for cooperation with Science Clubs of America which had not yet been completely worked out by the A. A. A. S. committee, of which he is chairman. Meetings of the national committee had been impossible to arrange for the current year.

The secretary reported several invitations from various groups for the 1944 annual meeting. The council seemed agreed that the invitation from Northern Illinois State Teachers College at DeKalb seemed especially appropriate, but the decision to accept this invitation was referred to the new council to be considered at its first meeting on Saturday, May 8.

No further business being before the group, the council was adjourned at 8:15 P.M.

(Signed) R. F. Paton, *Secretary*

REPORTS of the 36th ANNUAL MEETING

Illinois College and McMurray College, Jacksonville, Illinois
May 7-8, 1943

The preliminary business meeting of the Illinois State Academy of Science, assembled in annual session at Jacksonville, Illinois, May 7 and 8, 1943, was called to order by President F. M. Fryxell at 9:30 A.M. in Jones Chapel, on the Illinois College campus. The business of the meeting consisted solely of the announcement of committees appointed by the President for the transaction of the immediate business of the Academy. These committees were:

Nominating Committee: E. L. Stover, chairman, T. H. Frison, G. D. Fuller, H. K. Gloyd, V. O. Graham, and Gilbert Wright.

Resolutions Committee: Clarence Bonnell, chairman, J. S. Ayars, and W. F. Bailey.

Auditing Committee: J. Q. Sapp, chairman, A. R. Buis, and W. W. Thomas.

The committees having been instructed to report at the final business meeting, necessary announcements regarding meetings, meals and the Saturday inspection tours were made and adjournment until the final business meeting at 5:00 P.M. was voted.

The final business meeting was called to order by President F. M. Fryxell at 5:00 P.M. in room 17 of the Science Building on the MacMurray College campus

Reading of the minutes of the preliminary business meeting was dispensed with, since no business other than the appointment of temporary committees had been transacted.

The Treasurer, John Voss, made a brief report of income and expenditures and distributed to all persons present copies of a statement of the current financial condition of the Academy. He spoke of a small decrease in membership from a year ago, but emphasized that the financial status is better than a year ago and, in fact, is the best in the history of the organization.

Chairman J. G. Sapp reported for the Auditing Committee, finding the accounts of the Treasurer in order and correct and a balance of $1274.91 on deposit at the Commercial Merchants National Bank and Trust Company, in Peoria. Upon motion and vote, the report of the Auditing Committee was unanimously accepted; it was ordered to be filed with the Secretary for printing in the transactions.

The reports of officers, standing committees, and special committees were called for by the President. The Secretary pointed out that written reports of all committees were in his hands and that, since all reports would be printed in the June number of the Academy's Transactions, verbal reports could be omitted at this meeting unless special requests arose from the assembly. No such requests being put forward, the President ordered the omission of the reports of these committees.

The reports of temporary committees were then called for by the President.

Chairman E. L. Stover reported for the nominating committee, presenting a full slate of officers, committee chairmen, and committee members. Further nominations from the floor were called for by the President. No such nominations being advanced, the Secretary was instructed, upon motion and vote, to cast a unanimous ballot for all persons placed in nomination by the Nominating Committee.

Chairman Clarence Bonnell reported for the Resolutions Committee, reading separately the resolutions formulated by the Committee. Each resolution was discussed from the floor and, upon motion and vote, approved and ordered to be printed in the Academy's Transactions.

There being no further business, the formal meeting of the Academy was adjourned until 1944, the date and place to be selected by the Council.

(Signed) R. F. Paton, *Secretary*

LOCAL ARRANGEMENTS

With characteristic modesty, Dr. Willis De Ryke, chairman of the Committee on Local Arrangements, has preferred to let the work of his committee speak for itself in the convenience and efficient working of all arrangements made for the thirty-sixth annual meeting of the Academy at Jacksonville on May 7 and 8, 1943.

Arrangements with the Dunlap Hotel provided cordial welcome, quick service, and a pleasant atmosphere for Academy members as they arrived and during their stay. Luncheon arrangements and room assignments for committee and council meetings had been provided in advance and were in all cases well serviced, comfortable and adequate. The Committee's work and the hotel's cooperation were especially evident in provisions for the Social Science luncheon and the staging of the annual banquet which were successfully served at reasonable cost to the members and guests of the Academy under the trying conditions of war-time food rationing.

Arrangements made for the morning sessions at Illinois College included the provision of a room in the Tanner Memorial Library for registration and the making of luncheon and banquet reservations, the use of the Jones Chapel

for the preliminary business meeting and the general session of the Academy, and the opening for inspection of the oldest college building in Illinois, built in 1829, and the scene of William Jennings Bryan's early oratorical efforts as a literary society member.

For the sectional meetings and the final business meeting, arrangements were made for the use of Science Hall on the MacMurray College campus, at least eleven class rooms and laboratories being placed at the disposal of the Academy for the entire afternoon. An especially pleasant feature was the arrangement for the Academy's noon luncheon in the private dining hall of the President of MacMurray College, where service by MacMurray College was planned for over eighty persons.

For the annual lecture, the large auditorium in Jacksonviloe High School provided ample seating for the Academy attendance and was so closely located to the hotel that members had no difficulty in attending both the banquet and the lecture.

Of great interest, both in anticipation and in fulfillment, were the inspection trips to the State School for the Blind, the State School for the Deaf, and the State Hospital for the Insane, at each of which special demonstrations had been arranged. In spite of gasoline restrictions, adequate transportation to these institutions was provided through the use of busses, local automobiles, and the cars of Academy members.

In all of the arrangements Dr. De Ryke enlisted the full, active, and enthusiastic cooperation of all the administrative officers and staffs of the colleges and institutions established in Jacksonville. From his own institution, Illinois College, he had the active support of President H. Gary Hudson and Dean Earnest Hildner, and from MacMurray College he enlisted the support of President Clarence P. McClelland and several members of the faculty. From other organizations he drew also, enlisting Dr. James L. Smith of the State Hospital for the Insane, D. T. Cloud of the State School for the Deaf, R. W. Woolston of the State School for the Blind, and Derrell Blodget, Acting Superintendent of Shcools, each of whom, as managing officer of his institution, contributed so valuably to the success of the meeting as to merit special attention from the Resolutions Committee. Toward the hospitable atmosphere, as well as in other ways, the civic clubs of Jacksonville—Exchange, Kiwanis, Lions and Rotary—the Chamber of Commerce and the city government also contributed.

PUBLICITY

Serving as publicity chairman, Miss Grace Tickle, of MacMurray College, made use of the MacMurray College News Service, directed by Mr. Harold Gibson, for the distribution of news releases regarding the meeting of the Academy. Two releases went to 96 Illinois dailies.

One news release, dated for April 18, 1943, announced the coming meeting of the Academy in Jacksonville and gave in some detail the anticipated program, naming the special speakers and events. This release was used by the Jacksonville Daily Journal and, undoubetdly other newspapers.

A second release, dated for April 21, 1943, reiterated the announcement of the meeting and gave special attention to the scheduled address by Academy President F. M. Fryxell, on American Science and the Phillipines.

A third release, dated for April 28, 1943, publicised the appearance of Dr. Carl P. Russell of the National Park Service and Dr. Edson S. Bastin of the University of Chicago as special guest speakers.

The press of Jacksonville gave constant and interested coverage of the sessions and devoted 290 column inches to reports on the meetings and business transactions of the Academy.

REPORT ON THE PROGRESS OF THE COLLEGIATE SECTION

At the initial meeting of the Collegiate Section in Urbana on the Illinois campus in May, 1942, a committee of ten was chosen to draft a constitution for the Section. The chairman of this committee was Mrs. Martha Leavenworth, then a junior in the Botany Department of the University of Illinois. The committee drafted most of the constitution immediately after that business meeting and it was completed and slightly revised later by Mrs. Leavenworth and H. R. Wanless. This constitution was presented to the persons assembled at the business meeting at Jacksonville on May 7, 1943, and was unanimously adopted. The constitution is printed as a part of this report.

CONSTITUTION of the COLLEGIATE SECTION

Article I—*Name*

The name of this organization shall be the Collegiate Section.

Article II—*Purpose*

The purpose of this organization shall be to promote scientific interest among the colleges and universities of Illinois and to assist the Illinois Academy of Science in its program by constituting a section.

Article III—*Membership*

Any science club, society, or interested group not organized into a society in any college or university in Illinois shall be eligible for membership.

Article IV—*Delegates*

Each organization or group shall be allowed one delegate as a voting representative to the business meetings.

ARTICLE V—*Council*

SECTION 1. The powers and authority of this organization shall be vested in a council of ten members, representing different colleges or universities.

SECTIOX 2. The members of the council shall be selected as is practicable, from schools not represented on the council during the previous year.

SECTION 3 The members of the council shall elect a chairman who shall serve for the current year.

SECTION 4. The council shall transact such business as seems necessary and expedient for the perpetuation and advancement of the organization.

ARTICLE VI—*Meetings*

SECTION 1. The annual meeting shall be held at the time and place of the annual meeting of the Illinois State Academy of Science.

SECTION 2. The annual meeting shall consist of sectional meetings for the presentation of papers and reports and a business meeting for the selection of the council and the transaction of business.

ARTICLE VII—*Amendments*

This Constitution may be amended at a regular meeting of the organization by a two-thirds majority of the delegates attending and voting at the business meeting. Such amendments shall become effective on their approval by the Council of the Collegiate Section, or, if the Council does not approve the amendment, it shall become effective following a two-thirds majority of the delegates attending and voting at the business session of the year following that in which said amendment was proposed.

Letters were sent by Mrs. Leavenworth and H. R. Wanless to science teachers in about fifty colleges in Illinois in December and in March, requesting papers for this year's program at Jacksonville. A radio talk on the Collegiate Section was presented over station WILL on December 14. As a result of the letters a total of fifteen papers were offered for the Jacksonville program.

Mrs. Leavenworth graduated from the University of Illinois in February of 1943 and as she then left the state she was unable to be present and preside at the Jacksonville meeting. The following students of MacMurray College served as co-chairmen of the meeting: Miss Marjory Merrill, senior in biology, and Miss Eleanor Garvin, senior in chemistry.

All of the fifteen papers announced were presented. The attendance at the meeting was as large as forty during a part of the time and well over twentythroughout the meeting. The following persons were chosen members of the council for the following year:

BRIAN NEVILLE, *Loyola University*, Chicago.

FRANCES HAAS, *Rosary College*, River Forest.

BETTY O'CONNOR, *College of St. Francis*, Joliet.

ELIZABETH ANN LIVESAY, *University of Illinois*, Urbana.

MacMurray College representative to be named.

(Signed). H. R. WANLESS, *Coordinator*

REPORT OF THE EDITOR

Quarterly issues of the *Transactions* appeared during the year as follows:

June, 1942 vol. 34, No. 4. 24 pages. Contains a record of minutes of the four Council meetings; business transacted and reports made by officers, committees and delegates at the annual meeting held in Urbana in May 1942; Junior Academy listing of awards. Cost: $163.75. Paid with Academy funds.

September, 1942 vol. 35, No. 1. 24 pages. 13 illustrations. Contains special papers presented at the Urbana meeting, and memoirs. Cost: $297.46. Paid out of the State appropriation.

December, 1942 vol. 35, No. 2. 220 pages. 40 illustrations. Contains 83 papers submitted by 92 authors (10 articles had two or more authors) from the annual program for the Urbana meeting. 46 other papers from that program are listed by title only. Cost: $1039. Paid out of the State appropriation, augmented by $180 from the Illinois State Museum fund for publications; this loan will be paid after July 1st.

March, 1943 vol. 35, No. 3. 12 pages. Program of papers for the May meeting in Jacksonville May 7-8, 1943. Cost: $93.85. Paid with Academy funds.

(Signed) GRACE NEEDHAM OLIVER, *Editor.*

REPORT OF THE LIBRARIAN

Publication appropriations for 1943-1944 have been approved and it appears likely that they will suffer no severe reduction. A printing deficit of $180.00 was covered by the Museum during the past year. Since reduced budget requires more exact apportionment of available funds, printing expenses during the coming biennium must be kept within the amount stipulated for Academy use—$3000 for the two years.

Quarterly issues, volume 34, No. 4, to volume 35, No. 3, were sent out through the State Multigraph Bureau. Approximately two hundred

copies of each issue are in storage at the Museum. These, together with other back issues, are constantly drawn upon to supply needed copies by libraries and individuals. While Transactions addressed to Canada and other Allied nations have been sent out, those addressed to European institutions are held for the duration of the War.

Members having back issues of volumes before volume 23 who desire to dispose of their copies are invited to get in touch with the Librarian, as many requests are received for out-of-print numbers.

Several scientific societies were added to the exchange mailing list during the past year.

Through its exchange relationship, the Academy Library now contains a number of valuable serial publications. Members who would like to borrow from this library are invited to do so at any time.

Respectfully submitted,

(Signed) Gilbert Wright, *Librarian.*

REPORT OF TREASURER

For the fiscal year May 1, 1942 to April 30, 1943

Receipts

Balance on hand April 30, 1942		$1068.54
Dues and initiation fees:		
Annual members	$693.40	
Affiliated societies	11.00	704.40
Editorial and excess pages fees		132.55
Research grants by the A.A.A.S.		226.50
Interest from Forbes and Meyer real estate		9.00
Junior Academy:		
Dues	$ 86.10	
Sustaining members	200.00	286.10
		$2427.09

Expenditures

Officers' expenses	$ 41.93	
Section Chairmen expenses	71.39	113.32
Postage and printing, Treasurer's office		25.82
Postage and transportation of Transactions		23.45
Printing of Transactions		269.55
Expenses of Secretary		43.68
Lecture		26.96
Expenses of Editor		10.50
Conservation Council		2.00
Bank charge		.06
Research grants:		
W. M. Reed	$ 75.00	
W. W. Crawford	50.00	
C. C. Hoff	50.00	
M. E. Britton	51.50	226.50
Secretary, honorarium		150.00
Editor, honorarium		150.00
Junior Academy:		
Officers' expenses	$ 46.39	
Ribbons	7.70	
Printing	16.25	
Science Aids Service	40.00	110.34
		$1152.18
Balance in Commercial Merchants National Bank and Trust Company of Peoria		1274.91
		$2427.09

The membership of the Academy consists of 62 life members, 51 new members, 19 sustaining members, 539 members paid up to and including the year 1943, 106 members one year in arrears, 58 members two years in arrears, and 54 members three years in arrears.

The total membership not including the members who are three years in arrears is 835.

During the year 9 members have resigned, 5 have died, and 60 have removed leaving no forwarding address.

The Academy has added 8 new Junior Academies, 26 are fully paid up, 16 are one year in arrears, 13 two years in arrears, and 6 three years in arrears.

The present financial status is better than a year ago and it is the best in the history of the organization. Although the membership is less than a year ago, the increase in the balance is chiefly due to the light expenses incurred when the annual meeting was held at the University of Illinois.

We are very grateful to the sustaining members and especially to the Illinois High School Association for their generous support of the Junior Academy.

Respectfully submitted,

(Signed) John Voss, *Treasurer.*

This is to certify that we have examined the preceding accounts for the year May 1, 1942, to April 30, 1943, and find them correct. The balance of $1274.91 is on deposit with the Commercial Merchants National Bank and Trust Company of Peoria, Illinois.

(Signed) John Q. Sapp, *Chairman*
A. R. Buis
Walter W. Thomas

REPORTS OF COMMITTEES

The nominating committee submitted to the final business meeting of the Academy, in annual session at Jacksonville, on May 7, a slate of officers, delegates, committee members for 1943-1944. There being no other nominations advanced from the floor, the Secretary was instructed by motion and vote to cast a unanimous ballot electing the persons named by the nominating committee to various offices and committees.

See page 258 for officers; p. 260 for committees and delegates.

Respectfully submitted,

(Signed) E. L. Stover, *Chairman.*

The Publications Committee wishes to report that of the 83 authors publishing in the December issue, 60 were already members at the time the program was being formulated, 23 were not, but became members subsequently. This information may be of interest to the membership chairman, and to the secretary, who might wish to follow up new memberships with a systematic campaign for life members, or at least for second- and third-year memberships.

In an effort to facilitate earlier printing of the December issue, this committee, at the suggestion of the editor, will meet early in June instead of August to consider papers submitted for consideration. Thus any necessary re-working, and the editing, can be done in time to send out both the September and the December manuscripts concurrently. This will allow, therefore, more leeway for both the printer, who this past winter was unusually crowded with unexpected legislative printing, and the editor, who had extensive difficulty contacting authors widely dispersed on account of the war.

(Signed) F. M. Fryxell
Neil E. Stevens
R. F. Paton
H. J. Van Cleave

The Committee on Research Grants recomended that the research grant fund of $210.50 returned to the Illinois State Academy of Science from dues paid the American Association for the Advancement of Science be distributed in the following manner:

1. To Drs. I. A. Koten (Chemistry), H. J. Eigenbrodt (Biology), and C. L. Bieber (Geology), of North Central College for the purchase of a Fisher AC Model Electrophotometer to be used cooperatively in the determination of certain mineral elements in plant and animal tissues, and in Trenton Rock, $165.00.

2. To Dr. C. W. Bennett (Chemistry) of Western Illinois State Teachers College to study the action of nitric acid upon 9-acetaminofluorene, $45.50.

Respectfully submitted,

(Signed) L. H. Tiffany, *Chairman*

COMMITTEE ON HIGH SCHOOL SCIENCE CLUBS

The annual meeting of the Junior Academy of Science was not held this year with the State Academy of Science at Jacksonville. In accordance with the plan adopted by the committee on high-school science clubs individual schools were encouraged to hold their own meetings to which nearby schools could be invited. with exhibits judged by three qualified teachers, at least one of whom should be an Academy member. Six schools held local meetings at which other schools were in attendance. The schools are Normal Community H. S., Chester H. S., Aviston Community H. S., East Rockford Senior H. S., J. Sterling Morton H. S., and University H. S., Carbondale. The usual Junior Academy certificates were awarded.

A special vote of thanks is extended to Mr. Albert Willis, Mr. Louis A. Astell, Dr. Lyell J. Thomas, and Dr. R. F. Paton for their assistance in promoting this year's program.

The annual election of student officers was held by mail and the following officers were elected for 1943-44.

President: Joan Siegfried—Chester High School.

Vice-President: Frederick Wood, Mt. Carmel High school.

Secretary: Carol Kudra—J. S. Morton High School.

A. A. A. S. Honorary Delegates:

Norbert Haake—Aviston Community High School.

Bettie Johnson—Galesburg High School.

(Signed) Allen R. Moore,
General Chairman
S. Aleta McEvoy,
Assistant General Chairman.

The Committee on Resolutions, on its own behalf and on behalf of several members of the Academy, submits for the approval of the membership the following resolutions:

1. A resolution regarding the conservation of National Park resources.

Whereas: Under the stress of war there is a tendency on the part of production interests to be precipitate in the use of irreplaceable natural resources such as are represented in the superlative values of the National parks and monuments, and

Whereas: Search usually discloses sources of minerals, forage, and timber outside of these great museums of the out-of-doors, which can serve equally well in the war emergency,

Be it resolved: (1) that the Academy applauds the action of the Secretary of the Iuterior in the reaffirmation of the National Park Service policy of eliminating grazing from the National parks and monuments. It is the conviction of the Academy that the people of this nation desire to retain the National parks in their nautral condition. Further extension of grazing in these areas, therefore, should be prohibited unless and until it is demonstrated that there is no alternative and that the sacrifice of the park and monument biota will have to be made in the aid of winning the war.

(2) That the Academy recognizes the fact that the shortage of Sitka Spruce for airplane manufacture may be a threat to the safety of the virgin forests in Olympic National Parks. This park serves its highest public use by preserving for future generations a remnant of the vast forests that once were the glory of the Pacific Northwest. The spruce supplies of Oregon, Washington, and Alaska outside of national parks and monuments should be utilized first. If necessary, spruce logging operations outside of the parks should be subsidized by the government before the Olympic forests are further mutilated. *Necessity*, not convenience, must be the criterion.

(3) That the Academy heartily approves of the recent establishment of Jackson Hole National monument adjacent to the Grand Teton National Park. This area, rich in history and abounding in scientific and scenic values, complements the national park system in a manner most gratifying to all national conservation interests. It has a capacity to stimulate national pride in and understanding of our natural heritage and cultural tradition. Recognition of its unique values now is timely.

2. A resolution regarding education in the sciences.

Whereas: The present national emergency has called attention to the importance of sound education in the sciences, and

Whereas: Sound education in the sciences will continue to be of fundamental importance following the war, and

Whereas: Such education can be given only by well trained teachers of science,

Be it resolved. (1) That the Illinois Academy of Science, through its executive council, form a representative committee whose responsibility it shall be to formulate plans and policies concerning the preparation and certification of the teachers of the sciences in the schools of Illinois, to the end that thoroughness of preparation and ability in teaching standards be maintained at the very highest possible level consistent with the present situation, and

(2) That the Committee so formed shall seek to cooperate with the Office of the State Superintendent of Public Instruction in bringing such plans and policies into actual practice at the earliest possible time.

3. A resolution regarding mobilization of scientific personnel.

Be it resolved: (1) That, although the Illinois State Academy of Science wholeheartedly is in favor of science and scientists doing all they can towards winning the war, it is opposed to the proposed federal legislation, known as the Kilgore-Patman bill, S. 102, for mobilization of scientific and technical personnel and facilities, because, under the guise of advancing the use of science and technology in the war effort and for prosperity in peace, the bill actuallyplaces scientists and technologists under undesirable regimentation and political control, and

(2) That this resolution be conveyed to all Illinois congressmen.

4. A resolution in appreciation of the annual meeting arrangements.

Whereas: Under the exceptional difficulties imposed by the present war-time emergency, the City of Jacksonville, the colleges and state institutions, and numerous persons have contributed to the holding of a successful annual meeting of the Academy.

Be it resolved: (1) That the Academy extends its sincere appreciation of all the efforts put forth in its behalf to

The City of Jacksonville, including the City government, the Jacksonville Board of Education and Acting Superintendent Darrel Blodgett, and the Jacksonville press;

Illinois College, its President, Dr. Gary H. Hudson, and its Dean, Dr. Earnest Hildner;

MacMurray College, its President, Dr. Clarence P. MacClelland, and the several members of its staff who cooperated;

The State School for the Deaf, its Managing Officer, D. F. Cloud, and its staff;

The State School for the Blind, its Managing Officer, R. W. Woolston, and its staff;

The State Hospital for the Insane, its Managing Officer, Dr. James L. Smith, and its staff; and

The Committee on Local Arrangements, composed of Dr. Willis De Ryke, chairman, Miss Grace Tickle, publicity, Dr. W. F. Bailey, and Miss Helen Kamm; and

(2) That the Secretary be instructed to convey this appreciation in writing to each of the above named institutions and persons.

5. A resolution in appreciation of the services of the retiring Secretary.

Whereas: Dr. Robert F. Paton, Associate Professor of Physics in the University of Illinois, has served the Academy as Secretary since May, 1937, and

Whereas: During his six year's of service in the office of Secretary he has faithfully accomplished the duties of his office with efficiency, to the satisfaction and pleasure of the numerous officers and committees of the Academy functioning during that period, and to the satisfaction of the entire membership of the Academy.

Be it resolved: That the Academy, assembled in annual session, expresses in one voice its appreciation of his outstanding service, its regret that he cannot continue to serve as its Secretary, and its confidence that he will succeed in accomplishing the many new duties imposed on him by current war demands.

6. A resolution regarding deceased members.

Whereas: Death has removed from our midst the following valued members of the Academy:

Dr. William S. Bayley, Department of Geology, The University of Illinois, Urbana,

Dr. Charles J. Chamberlain, Department of Botany, The University of Chicago, Chicago,

Dr. William A. Noyes, Department of Chemistry, The University of Illinois, Urbana,

Dr. Earnest A. Pribram, Loyola University School of Medicine, Chicago, and

Miss Harriet Strong, Downers Grove,

Be it resolved: (1) That the Academy expresses its grief over their passing, and

(2) That it extends its sincere sympathy to their families, to whom the Secretary is directed to write letters indicating our sense of loss while we extend our sincere sympathy.

(Signed) Clarence Bonnell, *Chairman*

Committee on Affiliation. A letter was sent to all members of the Committee asking them to suggest societies which might be eligible for affiliation. In letters to science teachers at the colleges and universities of Illinois regarding the Collegiate Section it was suggested that science clubs, societies, or unorganized groups of undergraduate science students might be encouraged to affiliate with the Academy. It was later reported that a science club at Principia College, Elsah, Illinois, is applying for affiliation.

It was reported in several letters that science clubs have been suspended or are largely inactive because of the loss of a large proportion of the science students to the armed forces and the pressure of accelerated programs and specialized war courses.

It seems likely that there will be many science clubs which will wish to affiliate with the Academy when the universities and colleges are again able to resume normal programs.

(Signed) Harold R. Wanless, *Chairman*

The Committee on Conservation of Archaeological and Historical Sites has held no meetings during the year, as no critical situations have been brought to its attention. The main service which the Committee can render at this time is to be ready to take positive action when any of our important sites are endangered.

(Signed) Fay-Cooper Cole, *Chairman*

The Committee on Legislation and Finance will hold its next session at the time of the annual meeting of the Academy. Its chairman has been in constant touch with the State Museum through which the Society's Transactions are published, and it appears that this arrangement will be continued for the next biennium.

(Signed) Fay-Cooper Cole, *Chairman*

The Committee on the Budget begs to make the following progress report:

Your attention is called to the fact that some of these items are further elaborated in the report of the Treasurer. On May 1, 1943, the Treasurer's accounts showed a sizeable balance on hand, which indicates that the Academy is in good financial condition. The Committee, however, wishes to point out the existence of several factors which will undoubetdly influence the future of the budget. These trends are very clear: First, fewer new annual members are being added to the roll. Second, during this year there have been some resignations because of restriction on travel and increase in duties associated with the job of the resigning members. There have been some noticeable increases in the costs of operation. While these are, at the present, small, we should anticipate further increased costs in the operation of the Academy. The Committee further calls your attention to the needs which should be projected in terms of two or more years. With the anticipation of this decreased income, it is obvious that we should exert more effort to maintain our mem-

bership roll; if it is possible, to continue the campaign for new members. There is considerable need for more sustaining members. The Committee, therefore, recommends that the Academy:

I. Continue its effort to maintain the roll of annual membership.

II. Set up a special committee to add new sustaining members to the roll.

(Signed) C. L. Furrow, *Chairman*,

Knox College, Galesburg,
W. H. Voskuil,
State Geological Survey, Urbana,
John Voss,
Manual Training High School,
Peoria.

The Committee on Membership during 1943 has mailed out 2,000 copies of the invitation and application for membership. These were directed to college and university faculties and students and to the teachers in a few high schools who were not reached in our last year's correspondence. It is our hope that the Academy may continue to grow in membership and influence.

(Signed) John E Coe, *Chairman*.

The Committee on Pre-Medical Training submits the following report of its first year of work.

The Secretary of the Illinois State Academy of Science requested the formation of this committee late in 1942, on authorization of the Executive Committee. The general purpose was to study the present status of pre-medical training. At the meeting of the Academy in May, 1942, it was tentatively planned that this be made the subject of a symposium at the meeting for 1943. On account of the unsettled state of affairs just now, it has required most of the intervening time to secure the personnel indicated below. Even yet it seems that there might be a better balance, in that there is no chemist represented, no clinical representative from any other medical school than the University of Illinois, and probably insufficient representation from the smaller colleges, possibly also from the high schools. Members are urged to make suggestions as to additional personnel as early as possible.

L. I. Bockstahler, Department of Physics, Northwestern University, Evanston.

Harvey De Bruine, Professor of Biology, Elmhurst College, Elmhurst.

Edmund F. Foley, M. D., Associate Professor of Medicine, University of Illinois College of Medicine, Chicago.

B. Vincent Hall, Department of Zoology, University of Illinois, Urbana.

P. K. Houdek, Secretary-Treasurer, National Association of Biology Teachers, Township High School, Robinson.

A. B. Luckhardt, M D , Professor of Physiology, University of Illinois College of Medicine, Chicago.

John T. Reynolds, M. D., Department of Surgery, University of Illinois College of Medicine, Chicago.

C. I. Reed, Chairman, Professor of Physiology, University of Illinois College of Medicine, Chicago.

The chairman has, in addition to enlisting personnel, consulted many persons who are vitally interested in this problem and has formulated a tentative working program which is subject to modification according to the will of the committee.

1. Earlier planning for a medical career has been urged strongly by several. On the other hand, numbers of medical students object to this on the grounds that it might tend to narrow still further the scope of cultural training. Students have even emphasized the desirability of more knowledge of astronomy, geology, geography, genetics, botany, etc.

2. It has been urged that certain subjects be removed from the medical curriculum and placed in the premedical curricula, to be replaced by advanced applied courses. This would apply to portions of physiology and anatomy, all of biochemistry, also part of bacteriology. The time thus vacated would be given over to applied courses in these same fields.

There is much to commend these suggestions but there is again the objection that they would necessitate the displacement of other subject matter downward into Junior College or High School. Could we risk such changes?

3. There are many complaints from the medical schools about the training of students in one or another subject. Perhaps the most consistent comment is that the students are less thoroughly trained in physics and languages than they are in chemistry and biology. If this is true there may be many reasons for it other than those justifiably calling for criticism of educators. Your comments are solicited on the following points:

(a) Are deficiencies in scholastic attainment on the part of incoming medical students to be properly blamed on the quality of instruction in college or high school or are they due to other social factors?

(b) Do such deficiencies actually exist in comparison to other disciplines?

4. Disregarding the present state which is only temporary, can we arrive at any evidence as to whether the period of specialized premedical training should be increased, decreased,

or unchanged? Most medical men consulted to date have expressed the belief that the PM period should be *at least* 4 years. Many students are convinced that 2 years are sufficient. Laymen in general feel that doctors should have more cultural training.

5. One authoritative commentator has said, "I believe that meeicine has definite need for men who have had unusual training in such fields as mathematics, physics, economics, psychology, sociology and English, as well as biology and chemistry. I am not particularly interested in a student taking a fourth year in his premedical training if he has not developed some special interest during his previous three years in college."

Is the need indicated here sufficient to justify adapting the entire program to it?

6. Has anyone further suggestions as to further additions to personnel or direction of enlargement of the committee?

7. It does not appear to be practical to attempt a meeting of the committee until the work has progressed further.

8. All additional comments and suggestions will be incorporated into the program, if possible.

9. It seems best, at the moment, to confine activities to gathering evidence from additilnal sources, and from that formulating a further outline of action. However, that judgment is open to your respective comments. Please feel free to comment on every point. Any final recommendation or report must be thoroughly representative. I would like to have your reactions as soon as possible in order to make a further report to the Executive Committee of the Academy before the next annual meeting.

Respectfully submitted,

(Signed) C. I. Reed, *Chairman.*

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